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Tng.
J94F

JP

HARVARD UNIVERSITY
ARNOLD ARBORETUM
PRESENTED BY CHARLES SPRAGUE SARGENT
1892

DEPOSITED AT THE
HARVARD FOREST
1941

RETURNED TO J. P.
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1906.

Western Australian Timber Tests, 1906.

Since the preparation of the matter contained in the accompanying Report, and particularly of those portions referring to the strength of the Timbers of the Eastern States of the Commonwealth, various other data has been received, and notably a "Report issued by the Government of New South Wales in 1905," embodying the results of tests carried out since the publication of Professor Warren's test results in 1892.

In this report the strength of certain of the Timbers indigenous to New South Wales and Queensland are set down at figures considerably below those previously quoted, and it is to be presumed, therefore, that these later results are more nearly representative.

Taking, however, the whole of the data yet published concerning these Hardwoods, the comparatively small number of specimens tested, and the manner in which apparently they were selected and prepared (*vide* Professor Warren's report), precludes the acceptance of the resultant data as in any way conclusive.

It is the intention of this Government to conduct tests upon the most important of the valuable Hardwoods of Eastern Australia in a manner exactly similar to and with the same appliances as were used in the tests of the Western Australian Timbers, in the hope that the data thereby obtained, together with that embodied in the accompanying Report, may prove of value to Timber users throughout the world, and to all those interested in the Hardwoods of Australasia.

Whilst it is essential that the average strength of the various Timbers should be known, yet a high figure in this respect does not alone prove a Timber to be the best available for the work required, since two other factors, namely, "durability" and "quantity" available, are also of the highest importance. This is especially to be noticed in the case of "Jarrah," the strength of which is, as the accompanying Report shows, equal to all requirements, its "durability" as high, and the quantity available greater than that of any other Timber in Australasia.

NEWTON J. MOORE,
Premier of Western Australia.

28th September, 1906.

1906.

WESTERN AUSTRALIA.

Western Australian Timber Tests, 1906.

THE PHYSICAL CHARACTERISTICS

OF THE

HARDWOODS

OF

WESTERN AUSTRALIA.

BY G. A. JULIUS, B.Sc.M.E.

This publication is issued by and with the authority of the Government of Western Australia, as a Supplement to the "Notes *re* Timbers of Western Australia suitable for Railways, Engineering Works, and Constructional Purposes Generally," published by the Government of Western Australia, on 31st March, 1906.

8th August, 1906. NEWTON J. MOORE, Premier.

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BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

1906.

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WESTERN AUSTRALIAN TIMBER TESTS, 1906.

PREFATORY NOTE.

THE rational designing of timber structures of all kinds involves a thorough knowledge of the physical characteristics of the timber to be used.

Such information has not been available concerning the timbers of Western Australia, although, as it is hoped this report will show, they are to be classed amongst the most valuable of the world's hardwoods.

The Government of the State having decided that a full investigation was necessary, the matter was placed in the writer's hands, and, with the assistance of the officers of the Railway Department, and particularly that of his Chief, Mr. E. S. Hume, Chief Mechanical Engineer, he has been able to carry out a fairly complete series of tests, the data from which are briefly summarised in the accompanying Report.

It is hoped that the information therein contained may be of service in the development of the great timber resources of this State, and to the Engineer in enabling him to make the best use of the materials available.

The writer desires to make a special acknowledgment of his obligation to Mr. E. A. Evans and Mr. Kirkbride, of the Railway Workshops, for the very great assistance rendered by them in the preparation of the timber for test, and especially to Messrs. F. Shaw, G. F. O'Connor, J. M. Limb, E. Goodchild, and A. Cooper, and to those who worked under their direction, for the whole-hearted and painstaking manner in which they have carried out what has proved a very heavy and arduous work.

Many valuable samples were received from other Government Departments and outside firms, a full description of which accompanies the Report.

G. A. JULIUS.

Midland Junction,
21st July, 1906.

Report upon the Physical Characteristics of the "Hardwoods" of Western Australia.

INTRODUCTION.

An examination of all hitherto published results of the tests of the timbers indigenous to this State will show records varying to such a wide extent as to render them of little value for practical purposes.

Thus the tensile strength of Jarrah is given by three authorities, values of 2,940, 5,000, and 16,407 lbs. per square inch respectively, and similar wide discrepancies occur in the majority of the results, but in no case are sufficient data given to determine the cause of such differences.

Undoubtedly the most complete and valuable timber tests yet reported are those conducted for the United States Government upon the timbers indigenous to that country, and a study of these tests, which were carried out under the direction of the late Professor J. B. Johnson, and quoted by him in his classical work upon the "Materials of Construction," clearly determines the cause of the great divergency in the results obtained from timber tests, namely "*variations in the percentage of moisture present in the timber.*"

He reports that "with all the species tested (United States timber) the strength at 12 per cent. moisture is some 75 per cent. stronger than the same sticks are, either green or when wet through, after seasoning."

He further states that "it is the absence of any determination of the moisture condition of the test material that vitiates practically all tests of the strength of timber. Since large timbers require many years to season or dry in the open air, while small test sticks dry out very quickly, it is certain that the difference in the moisture conditions will fully explain the marked differences which have been observed in the strength of identical material in different sizes. It is to be hoped that in future all tests of the strength of timber will be so made as to fully reveal this condition as a definite percentage of moisture across the section near the region of failure." (See "Materials of Construction," page 668.)

In view of the necessity for a complete and final determination of the physical characteristics of our timber, owing to the contradictory nature of all existing records, it was decided to conduct the whole of the tests in such a manner as to fully satisfy the conditions laid down by Professor Johnson. As a result it has been found necessary to carry out over 16,000 tests, the data from which are summarised in this report, which "data" completely, and, it is to be hoped, finally establish the timbers of this State in a position at the head of the timbers of Australasia, and in the front ranks of the world's hardwoods.

SCHEME OF TESTING.

When timber is used for constructional purposes, it may be subjected to any of the following stresses:—

(*a.*) "Transverse" or "cross bending" stresses, as in beams which give rise to tensile, compression, and shearing stresses in the material.

(*b.*) Direct "tensional" stresses occurring in the tension members of framed structures.

(*c.*) Direct "end" compression stresses, occurring in the compression members of "struts" of framed structures and in columns, etc.

(*d.*) "Cross" compression stresses occurring wherever a "loaded beam" is supported by a column, or upon a second beam, and also in the case of sleepers where they carry the rails.

(*e.*) "Shearing" stresses along the fibres occurring frequently where timber is used for joints or "keys" in framed structures, and also along the "neutral axis" of beams.

(*f.*) "Combined shearing" and "compression" stresses set up in timber when subjected to blows on end, such as occur in the case of "piles" when being driven, and in "mall" heads, etc., as also to a lesser extent in the case of columns carrying a live load, such as railway bridges, piers, etc.

To satisfactorily determine the "strength," both "ultimate" and "within the elastic limit," of the various timbers of this State, the following tests were conducted:—

(1.) Tests in cross bending, the timber being used as a beam, supported at the ends and loaded centrally.

(2.) Tensile tests.

(3.) End compression tests, the load being applied "endwise" upon specimens of various dimensions, and ratios of "length to breadth."

(4.) "Cross" compression tests, the load being applied across the fibre of the material.

(5.) Shearing tests along the fibre of the material.

(6.) "Hardness" tests determined by the resistance to penetration, under both "steadily applied" and "suddenly imposed" loads.

(7.) "Spalling" tests, which were arranged to record the resistance opposed to splitting and crushing under repeated blows "on end."

In addition to the above, tests were made to ascertain the "holding power" of the various timbers upon Railway "dog spikes" both with green and dry timbers, with spikes newly driven, and with those that had been in place in "sleepers" for a varying number of years.

Chemical tests were also conducted to determine the nature of the sap present in the various timbers and its effect upon metals, etc.

In order to comply with the conditions laid down by Professor Johnson, "moisture" tests were made on sections taken from every specimen tested under the above headings, these "sections" being cut immediately after the completion of the "physical" test concerned, and the moisture condition determined in the manner hereinafter described.

Professor Johnson has stated that it has been found sufficiently accurate in the case of the American softwoods to calculate the strength of the large beams from the results of tests on small specimens, this being due to the comparatively low "strength" of these timbers, and the large size and uniformity of the trees from which they are cut.

In the case of the majority of the Australian hardwoods, this assumption cannot be made, as the "direction" of the fibres in the hardwoods is not so uniformly even as it is in the "softwoods"; and since the individual strength of these fibres is very much greater in the former than in the latter, any deviation between the direction of the fibre and the direction of applied stress is felt to a correspondingly greater extent in the hardwoods, and such deviations naturally occur more frequently in large than in small specimens.

For this reason Cross bending tests have been made upon specimens varying in size between 1in. x 1in. and 12in. x 8in. at all degrees of moisture, and the results obtained have fully borne out the above contentions.

As was to be expected, the timber that has shown the least divergency between the results obtained with the large and small specimens, is "Karri" (*E. diversicolor*), due, no doubt, to the very large size of the trees and the comparative straightness of the grain.

In order to render the data obtainable from these tests in a form suitable for practical use, the average results have been plotted as "curves" (published herewith), which show clearly the strengths of each of the timbers in beams of varying dimensions, and at all degrees of moisture between "green" and "dry."

SUPPLY AND PREPARATION OF TEST SPECIMENS.

As it was of importance that the results obtained from these tests should fairly represent the average qualities of the various timbers, specimens, wherever possible, were taken at random from the contract supplies of timber to the various Government Departments.

Other specimens were supplied by various private timber companies, notably the Millar's Karri and Jarrah Forests Co., Ltd., from their stocks.

In many cases both dry and green logs up to 4ft. in diameter were supplied, and these were broken down for tests at the Government Workshops, and the whole tested so that the results obtained may with certainty be taken to represent a true average.

The accompanying Schedule, No. 2, gives particulars of all the timbers received, which included the following varieties and quantities:—

Local Name.	Systematic Name.	Approximate quantity received for test, super. feet.
Jarrah	E. marginata	3,900
Karri	E. diversicolor	2,700
Tuart	E. gomphocephala	3,050
Wandoo	E. redunca	3,720
Blackbutt	E. patens	4,400
Red Gum	E. calophylla	3,200
Yate	E. cornuta	1,160
York Gum	E. loxophleba	1,580
Salmon Gum	E. salmonophloia	241
Morrell	E. longicornis	417
River Banksia	Banksia vehticillata	354
Native Pear	Xylomelum occidentale	133
Jam Wood	Acacia acuminata	40
Sheaoak	Casuarina Fraseriana	262
Swamp Oak	Casuarina	197
	Total	25,354 sup. ft.

Each specimen as received was, if necessary, broken down, then machined and planed on all sides, micrometrically measured, and weighed, preparatory to being tested transversely.

After this test, the fractured portions and the requisite moisture sections were cut out of the middle, and the ends of the specimens again machined for other varieties of tests; and after each successive test a further moisture section was taken close to the fracture.

No artificial seasoning of any kind was adopted with any of the samples, the beams, after machining, being stacked horizontally under a roof only until required for test.

Many interesting samples of timber that had been in service for a great number of years were received for examination and test, particulars of which are given hereafter.

A very great number of tests were made upon each of the more important timbers, in order to obtain "true" averages. Much of the contradictory nature of previously published test results has arisen from the inadequacy of the number of specimens.

Thus in the tests of W.A. timbers (Jarrah, Karri, and Red Gum) carried out at Sydney University, upon the results of which have been based almost the whole of the condemnatory reports of these timbers, only 14 samples were tested in cross breaking and a corresponding number in each of the other classes of test, or an average of under five per timber.

In the present investigation, the following number of tests have been made, upon the seven timbers of the greatest value:—

	Totals.	Average per variety.
Cross breaking	1,749	250
Tension	450	64
End compression	2,028	290
Cross compression	713	102
Shearing along the grain	654	93
Hardness, etc	873	125
Moisture	6,467	924
Totals	12,934	1,848

METHODS OF TESTING.

Appliances used.—The greater part of the testing was carried out with a 40-ton horizontal testing machine, specially designed and built in the year 1902, by Messrs. Joshua Buckton & Co., of Leeds, England, to meet the requirements of the Railway Department. Plates Nos. 15 to 25 clearly show the arrangement of this machine, which has admirably fulfilled the duties required of it.

Many new appliances have been fitted to it since its erection, and it is now capable of dealing with cross-bending tests on beams up to 30 feet span; tensile tests on specimens up to 40 feet in length; compression and column tests to 12 feet in length; torsion tests up to 45,000 inch lbs., and, in addition, is fitted with special appliances for shearing, and cross compression, etc.

To assist in the tests of timbers it was equipped with a specially designed autographic stress strain apparatus, which will accommodate a diagram two feet square, and also with an automatic electric beam-balancing mechanism, which has been used throughout the test with complete success (descriptions of both these appliances are given in Appendices 1 and 2 respectively).

The whole machine was overhauled before testing commenced, and twice during the progress of the work, and the "knife edges," etc., maintained in good condition.

The "load" is applied hydraulically, and the required water, under pressure, is supplied from a special accumulator, which is pumped up between tests, the pumps being stopped during testing to ensure evenness of loading and absence of all shock.

In addition to this testing machine, a small 8-ton machine was built to deal with the lighter tests, and the tests with the holding power of dog spikes. In this appliance the load is applied hydraulically from an accumulator and measured by a water balance.

"Impact" and "Spalling" tests were made on a dead-weight apparatus equipped with automatic "lift" and "release," and deflection-measuring gear, the blow being taken on an anvil weighing one ton, carried upon 1in. rubber pads on a solid 4in. floor.

"Moisture" tests were made upon thin sections (1/16in.) cut as close to the fracture as possible, and within 24 hours of testing. These sections were immediately weighed upon a No. 5 "Oertling" Chemical Balance, then placed in sets in a water oven, and there maintained at a constant temperature of 240° F. for a period of four hours, after which they were again weighed, and the loss determined.

The oven was specially designed to deal with this work, and is shown on Plate 14.

Cross Bending Tests were carried out on spans varying between 3 feet and 10 feet, depending upon the size of the specimen. The deflection multiplied by 20 was automatically recorded upon a special scale from which the moduli of elasticity have been computed. Notes were taken throughout the tests as to the behaviour of the specimens, and the nature and location of the "failure."

The loads were applied to produce uniform rates of deflection depending upon the span, that for 5 feet span being $\frac{1}{4}$-inch per minute.

Tensile Tests were carried out on turned specimens, the nominal "reduced" diameter of which was 1in.

These were held in special grips as shown on Plate No. 25, and an autographic stress strain diagram was taken with each specimen, from which the moduli of elasticity have been calculated.

No trouble was experienced in holding the specimens, except that in a few cases where the tensile stress was high the reduced portion pulled through one or both of the enlarged ends, an example of which is shown on Plate 25, this occurring chiefly in testing "Karri," which has a relatively low shearing strength along the grain. The average rate of loading throughout the test was $1\frac{1}{4}$ tons per minute.

Tests in End Compression.—These were all carried out between accurately squared steel tables, the ends of each specimen being ground true and square with its axis in a machine specially prepared for this purpose. All columns were of square section, owing to the large amount of labour that would have been involved in turning them to a circular section.

The end deflection multiplied by 100 was automatically recorded on a special scale from which, in the case of specimens failing in direct compression, the moduli of elasticity were calculated.

In the case of "long" columns, the "lateral" deformation was autographically recorded relative to the end section of the specimen by means of the apparatus shown on Plate 16. This was done to determine the direction relative to the "annual rings" on the section, in which the various timbers tended to deflect laterally. The rates of loading were maintained within pre-determined limits depending upon the size and length of the specimen.

Tests in Cross Compression were carried out in two ways, as follows:—

(1.) On specimens square in section, the length nominally twice the breadth, and the load applied over the whole of one side face.

(2.) On specimens square in section, the length nominally four times the breadth, and the load applied through a steel plate 4in. in width with square corners, which took its bearing upon the specimen on one side face, the opposite side face being supported over its whole surface.

In practice the load is more frequently applied in the latter manner.

In both methods, two arbitrary limits were chosen to determine the points of "initial" and "total failure," the first being that point at which the deformation equalled 3 per cent. of the depth of the specimen, and the latter when 15 per cent. of the depth was reached.

These limits are the same as those that were adopted for the United States Government tests.

The two "points" were automatically determined by an appliance shown on Plates 17 and 18, which is similar to that used by Professor Johnson, and described by him in his "Materials of Construction."

This apparatus, of which a description is given in Appendix No. 3, dispenses with all calculation in the determination of the two limits, and was found to be both convenient and accurate. The average rate of loading in these tests was $1\frac{1}{4}$ tons per minute.

Shearing along the Grain.—This test has also been carried out in accordance with two distinct methods, as follows:—

(*a.*) The specimens were prepared as shown on Plate 23, and the load applied by means of a "round backed" self-adjusting cotter which pulls out the "end" of the mortise (see Plate 56). In this method the section under test is sustained only by the resistance opposed by the material to "shearing along the grain," and there is no doubt that the results obtained in this manner accurately represent the true strength of the material in this direction.

The specimens were mortised in a "Chain Saw" mortising machine, which cuts the necessary slots "clean" and without shock to the timber.

This method is due to Professor Johnson, and is that adopted throughout the United States Government tests.

(*b.*) As the above arrangement gave results uniformly much below those obtained by Professor Warren when testing the timbers of Australia (including Jarrah and Karri), it was considered advisable to also carry out tests by his method, which is clearly shown on Plate 24.

As was to have been expected, very much higher results were obtained, particularly with "curly grained" timber, and an examination of the fractures (see Plates 60 to 64) has shown that the "enforced" failure along the plane defined by the apparatus results in a tensile stress being brought to bear upon many of the fibres, thus greatly raising the ultimate "shearing" stress.

Timbers tested in this latter method give results uniformly, from 75 per cent. to 100 per cent. higher than when tested under method "A."

Tests for Hardness.—A "hard" wood has been defined as one requiring a load in excess of 1,000lbs. per square inch to produce an indentation of one-twentieth of an inch.

Tests were made to determine this factor, which is of considerable importance in sleepers, upon specimens 12in. x 3in. x 2in. The load was applied through a circular steel die nominally one square inch sectional area, and the "instant" of obtaining a penetration of one-twentieth of one inch was automatically recorded by the apparatus shown on Plates Nos. 17 and 18.

The relative hardness was also derived by measurement of the penetration produced by a weight of 40lbs. falling from a height of five feet on to the specimen, which was held firmly upon a machined surface that formed portion of an anvil of one ton weight.

The requisite height of drop was previously determined by experiment, and was sufficient to produce well-defined differences in penetration, but not so great in the majority of cases as to split the timber.

To afford means for comparison, a number of samples of "American oak" and "Selected Indian" teak were tested for hardness by both methods, and the results are given hereafter.

SPALLING TESTS were made upon turned specimens, three inches in length and four square inches in sectional area, by allowing a 40lb. weight to fall upon them from a height of five feet, the specimens being placed on "end" on the one ton anvil.

The number of blows required to produce certain "deformations" upon the specimens, as recorded automatically, were taken as a measure of the resistance to "breaking up under shock" by comparison with the results obtained on similar tests of American oak and Teak.

TESTS TO DETERMINE THE HOLDING POWER OF DOG SPIKES IN SLEEPERS were made with both old and new sleepers, the old sleepers being drawn from the "road" by withdrawing two out of the four spikes, thus allowing the sleeper to be removed without disturbing the remaining two spikes.

These were then "pulled out" by means of the apparatus shown in Plate 26, the "pull" required to "start" the spike being recorded, as also the size and type of spike. New holes were bored in the "old" sleepers and the spikes re-driven, to be again pulled out in order to determine the holding power of the "used" sleepers upon the freshly-driven spikes. Similar tests were also made upon new sleepers.

All of the spikes were $\frac{5}{8}$in. square, and, with the exception of several of the oldest sleepers, were of the standard pattern marked B on Plate 26, and had been driven into holes bored with a $\frac{5}{8}$in. auger.

CHEMICAL TESTS OF SAPS were carried out in the Department's Laboratory, the sap being obtained from fairly green samples of the timbers when placed under a 120-ton hydraulic press.

CALCULATION FROM TEST RESULTS.

To ensure a thorough understanding of the methods adopted in arriving at the results given on the accompanying "test sheets," and to assist in the practical application of the data therein contained, the following brief statement of *formulæ* and methods is given :—

Moisture percentages as obtained from sections cut from specimens and dried—

Moisture per cent. of total weight $= \frac{W1 - W2}{W1} \times 100$ where W1 = weight of section before drying, and W2 = weight of section after drying.

In all the accompanying diagrams the "strengths" are given for various degrees of moisture expressed as a percentage of the "dry weight" of the material, which is obtained as follows :—

Moisture per cent. of "dry" weight $= \left(\frac{M}{100 - M}\right) \times 100$ where M = moisture per cent. of total weight.

Specific Gravity.

Each specimen was weighed and measured before the cross compression test, and its moisture percentage taken immediately after that test.

From this data, the following calculations were made in each case: —

Total weight per cubic foot $= \frac{W}{C}$ lbs.

Where W = Weight of specimen in lbs.
and C = cubic contents expressed in cubic feet.

Dry weight per cubic foot = W (1 — M) lbs.
Where W = total weight per cubic foot.
and M = moisture per cent. of total weight.

Cross-bending Tests.

W = breaking load at centre of beam in lbs.

D = deflection in inches per ton of load within the elastic limit as determined by the stress-strain diagram.

We = load (in lbs.) on the beam at the "Apparent Elastic Limit" as determined from the stress-strain diagram.

This "limit" is defined as "the point on the stress strain diagram of any material, in any kind of test, at which the rate of deformation is 50 per cent. greater than it is at the origin.

B = breadth of beam in inches.
H = depth of beam in inches.
L = span in inches.

Then,

Ultimate extreme fibre stress $= \frac{3\,W\,L}{2B\,H^2}$ lbs. per square inch.

Extreme fibre stress at Apparent Elastic Limit $= \frac{3\,We\,L}{2B\,H^2}$ lbs. per square inch.

Modulus of elasticity $= \frac{L^3}{4DBH^3}$ lbs. per square inch.

End Compression Tests.

B = Breadth, or minimum lateral dimension of column in inches.
H = "Depth," or "maximum" lateral dimensions in inches.
L = Length of column in inches.
W = Load at failure in lbs.
D = Reduction in length (in inches) per ton, of load within the elastic limit for "short columns."

Then "Radius of Gyration" $= \frac{B}{\sqrt{12}}$

Ultimate load per sq. inch $= \frac{W}{B\,H}$ lbs.

Modulus of Elasticity for "short" columns $= \frac{2240L}{B\,H\,D}$ lbs. per sq. inch.

Cross Compression Tests.

(a.) *Load applied over whole surface—*
W = Total load in lbs.
L = Length of specimen in inches.
B = Breadth of specimens normal to direction of loading in inches.

Ultimate load per sq. inch $= \frac{W}{L\,B}$ lbs.

(b.) *Load applied through steel plate—*
K = Width of plate in inches.

Ultimate load per sq. inch $= \frac{W}{K\,B}$ lbs.

Tensile Tests.

W = Total load in lbs.
D = Elongation produced by one ton load (within elastic limit).
A = Sectional area of specimen in sq. inches.
L = "Gauge" length of specimens, *i.e.*, length over which the elongation is measured.

Then Ultimate load per sq. inch $= \frac{W}{A}$ lbs.

And Modulus of elasticity $= \frac{2240L}{A\,D}$ lbs. per sq. inch.

Shearing Tests.

METHOD A.

W = Total load in lbs.
B = Breadth of specimen in direction of "slot" in inches.
D = Depth of material between "slot" and "end" in inches.

Load per square inch $= \frac{W}{2\,B\,D}$ lbs.

METHOD B.

W = Load in lbs.
B = Breadth of specimen in inches.
L = Length of specimen in inches.

Load per square inch $= \frac{W}{B\,L}$ lbs.

Hardness Tests.

W = Total "static" load in lbs.
D = Depth of indentation = 1/20th inch in these tests.

Load per square inch to produce 1/20th inch indentation $= \frac{W}{A}$ lbs.

RELATIONSHIP BETWEEN DIRECTION OF LOADING AND "END SECTION" OF SPECIMEN.—As the position in the tree from which a specimen is cut, and the direction of loading relative to the "annual rings" and "radial lines" as shown on the end section of the sample, are of considerable importance, particularly in cross bending, a complete record of these sections was kept for all tests, and these are included in the schedules of detailed results. The method of notation adopted in this record is shown on Plate 13.

RESULTS OF TESTS.

The data obtained from these tests, which exceeded 16,000 in number, are summarised upon the accompanying schedules and diagrams, and may be considered under the following headings:—

(1.) General summary of results expressed in such a form as to be comparable with the information available concerning other hardwoods.

(2.) Detailed description of the general results of the tests, with special reference to the effects of seasoning upon the strength, and the relative strength of members such as "columns" and "beams" of varying dimensions.

(3.) Consideration of the results of those special tests which cannot be classed under the general heading, such as the chemical tests of "saps," the holding power of "dog spikes" in sleepers, and the possibilities of the satisfactory treatment of the various timbers to enable them to resist the attacks of dry rot and white ants, etc.

1. GENERAL SUMMARY OF RESULTS.—Undoubtedly the most satisfactory method of "expressing" the characteristics of our timbers, many of the most valuable of which are yet practically unknown, is by comparison with those of well-known hardwoods indigenous to other parts of the world; and in order that such a comparison may be of value, it is essential that all results should be expressed in accordance with a "common" standard.

This has, as far as possible, been done in the accompanying Schedule No. 1 (folded sheet at end of report), in which is given the "strength" of the Western Australian hardwoods, as determined by the present series of tests, and also that of the most important of the "hardwoods" of the Eastern Australian States and of other parts of the World.

The whole of the figures given for the Western Australian timbers represent their "strength" when containing an amount of moisture equal to 12 per cent. of the dry weight of the wood, this being the standard adopted in the United States Government tests.

The results of the tests of the American Ash and Hickory, and of "Djatti," are also expressed in accordance with this standard, which is probably the fairest that can be adopted, although higher results are obtained from still dryer timber.

In the case of the figures given for the New South Wales hardwoods, which are also common to Queensland, the exact degree of "seasoning" is unknown. These figures are taken from Professor Warren's tests of Australian timbers published by the New South Wales Government in 1892, and represent the average strength of those specimens that had been "cut" and "seasoned" for at least 12 months, and in most cases for over two years, prior to being tested; and from experience obtained here with specimens of a similar size, the moisture percentage at the end of 18 months would be at least as low as 12 per cent., and in most cases below that figure. Hence the comparison made between the timbers of the two States is, if anything, favourable to those of New South Wales.

With regard to the results quoted for the timbers of Victoria and Tasmania, which are taken from Mr. James Mann's work on Australian timbers published in 1900, no information is available concerning their moisture conditions.

The figures given for English Oak, Teak, and Lignum Vitæ are for "seasoned" timbers, and are all quoted from the works of reliable authorities, whilst those for American Oak and Hickory are from Professor Johnson's work on the "Materials of Construction."

The data given in this schedule may therefore be accepted as accurately representing the strength of the timbers of this State, both directly and by comparison with the results quoted for other hardwoods.

On Plate No. 1 is shown a graphical summary of the strength of 21 of the most important of the Australian hardwoods, and it is to be remarked that six out of the first eight places are held by Western Australian timbers, and that two of them, and one to a most marked degree, are superior to the New South Wales Ironbark, which comes third on the diagram.

Against each timber is given the number of specimens tested, and the large number of such tests in the case of Western Australian timbers entirely precludes the suggestion that "picked" specimens only have been dealt with, as does also the method in which the samples were obtained.

2. Detailed Description of the Results of the Tests.—From the figures given on Schedule No. 1 the following deductions have been made:—

A.—Specific gravity, and its relation to strength.

The heaviest of the Western Australian timbers, and of all the Australian timbers of note, are Yate and Wandoo, which when first cut both average 79lbs. per cubic foot, Tuart and York Gum following closely with weights of 78 and 77 lbs. respectively.

When seasoned, *i.e.* at 12 per cent. moisture, Yate and Wandoo are still the heaviest, with Tuart, York Gum, Salmon Gum, and Morrell following in that order.

It has been stated that the weight and density of a seasoned timber is to a certain extent a measure of its strength, and this is borne out in the the case of Yate, which is the heaviest and very much the strongest of the Australian hardwoods; and although Wandoo and Tuart do not come next in order of strength, yet both are well to the front.

It is more nearly correct, however, to state that, the greater the density and therefore the weight, the greater is the strength to resist Compressive strain, whether applied edgewise or crosswise; and this is fully borne out by the results of the tests, in which the relative positions are, Yate, Wandoo, Morrell, Tuart, Salmon Gum, and York Gum.

It has been found that the "density" is no criterion as to the "Tenacity" or Tensile strength of the material, and hence, therefore, affords no guide as to the relative strength of beams which largely involves the tensile strength of the timbers. Thus, Karri, which when seasoned is lighter and less dense than any of the above-mentioned timbers, is very much stronger in tension and as a "beam" than all others, excepting Yate and Salmon Gum.

Red Gum also, which is comparatively light when seasoned, is very strong in tension, although not so high when used in beams, due to its lower compressive strength.

Generally speaking, the following deductions may be accepted:—

(1.) Timbers in which the grain is closely twisted and interwoven are in general very hard, dense, and heavy; high in compressive strength both edgewise and crosswise, and also in shearing strength along the grain; comparatively low in moisture, and, relatively to the straight-grained timbers, are lower in tensile strength, and therefore to a certain extent less strong where used as "beams." Such timbers are Wandoo, Tuart, and York Gum.

(2.) Timbers in which the fibres are straight and even, are relatively less hard and dense, and are lighter; considerably higher in moisture percentage when green; stronger in "tension," and therefore generally stronger as beams, but are correspondingly lower in compressive strength and in shearing strength along the grain.

Such timbers are Karri, Red Gum, Blackbutt, and Jarrah.

(3.) Timbers lying midway between these two conditions, although not so "dense" and "hard" as those coming under the first heading, are in general stronger than either; such timbers being Yate, Salmon Gum, and Morrell.

(4.) Timbers coming under the first and third headings in general are to be found either in districts where the rainfall is comparatively light (such timbers being Wandoo, York Gum, Salmon Gum, and Morrell) or in localities where the soil is porous and does not retain the moisture, such as the sandy country to which Tuart is almost wholly confined.

The straight-grained timbers are to be found in districts with a heavier rainfall, and particularly in soils that hold the water.

(5.) In every case, in the timber grown in the dry districts—viz. Wandoo, York Gum, Salmon Gum, and Morrell—the moisture percentage is very low, the average of the four, when green, being 28 per cent., and the sap is of a thick viscous nature. These timbers, when cut, season very slowly, and shrink to a comparatively small extent in seasoning.

In timbers growing in loose "porous" country, such as Tuart and Yate, the moisture percentage is higher, averaging 37 per cent., and the sap is of a more fluid nature.

These "season" more rapidly, but shrink very little in the process, this being markedly the case with Tuart.

In the straight-grained timbers—Karri, Jarrah, Red Gum, and Blackbutt—the moisture percentage when green averages 60 per cent., the sap being very fluid; and these timbers season more rapidly and shrink to a greater extent than those with lower initial moisture.

Cross Bending Tests.—The general results of these tests on beams of various sizes are clearly shown on diagrams Nos. 3 to 8. The curves there given clearly demonstrate the very great variations in strength at different degrees of seasoning, thus fully bearing out Professor Johnson's contentions in this respect.

From these curves and other data obtained in testing, the following information has been derived:—

(1.) The ultimate extreme fibre stress for beams of various sizes at 12 per cent. moisture lies between an average of 22,500lbs. per square inch for small Yate scantlings (up to 10 square inches sectional area) and 12,600lbs. per square inch for heavy Blackbutt beams, the actual figures being summarised on Schedule No. 3. It is seen that at 12 per cent. moisture, small beams up to 10 square inches section are from 10 per cent. to 16 per cent. stronger than beams of sizes between 20 and 25 square inches section, whilst heavy beams (30 to 40 square inches) are from 8 per cent. to 22 per cent. weaker.

As was to be expected, the least variation (8 per cent.) was obtained with Karri, owing to the large size of the trees and the evenness of the grain, Tuart and Blackbutt following next for the same reason; and the greatest variation (22 per cent.) occurred in the case of Red Gum, due to the presence of gum veins in the larger beams.

(2.) At 12 per cent. moisture the strength at the Apparent Elastic Limit lies between 89 per cent. and 69 per cent. of the ultimate extreme fibre stress, Tuart and Jarrah occupying the extreme positions respectively.

(3.) At 12 per cent. moisture the average modulus of elasticity lies between 2,800,000 (Yate) and 1,800,000 (York Gum).

It was found that in those timbers with high moisture percentages, *i.e.* Jarrah, Karri, Red Gum, and Blackbutt, the modulus of elasticity was equal to 150 times the Ultimate Extreme Fibre Stress.

In the case of Yate and Tuart, this ratio fell to 136, and for the dry timbers—Wandoo, Salmon Gum, York Gum, and Morrell—its value was 131.

(4.) For average size beams (25 square inches section), the percentage reduction in strength between "seasoned" and "green" timber varies from a maximum of 33 per cent. in the case of Karri and Tuart to a minimum of 14 per cent. for Wandoo.

(5.) As the percentage of moisture increases, the relationship between the strength of beams of various dimensions remains fairly constant.

(6.) In general, the strength of beams cut on the "quarter" was 12 per cent. less than that of square cut beams.

In carrying out the cross bending tests an endeavour was made to test an equal number of specimens cut square, partly on the quarter and wholly on the quarter, so that the results obtained might be true averages, it being impossible, commercially, to entirely avoid the use of "quarter cut" timber except in the most important works.

(7.) It is to be noted that the strength of the weakest of the West Australian "Eucalypts" is equal to that of hickory, and is 20 per cent. greater than that of the best oak.

SHEARING STRENGTH ALONG THE GRAIN.—The results of tests carried out in accordance with both the previously described methods are given in Schedule No. 1, and the wide discrepancies between the data derived from the two is to be noticed.

The average value of the true shearing strength (as determined by Professor Johnson's method) is 58 per cent. below that obtained by the Sydney University method, the difference being more marked in the case of "curly-grained" timber.

Plates Nos. 60 to 64 clearly show the large number of fibres which are subjected to and fail under a tensile strain when the specimens are tested under the second method.

As previously pointed out, the "shearing" strength of the hard, dense, dry timbers is generally higher than that of straight-grained, moist-grown wood.

STRENGTH IN CROSS COMPRESSION.—In the results of this test it is to be noted that when the load is "confined" to a portion of the specimen only, as is usually the case in practice, the strength in cross compression is on the average 12 per cent. higher than is the case when the load is applied over the whole surface.

Plates Nos. 10 and 11 show diagrams illustrating the relationship between the cross compressive strength and "seasoning." One feature is particularly noticeable, namely, that although Wandoo, Tuart, and Yate are very much stronger in cross compression, yet with these timbers an increase in moisture is followed by a considerably greater reduction in strength than is the case with the comparatively weaker timbers, Karri and Jarrah, etc.

TENSILE STRENGTH.—The tensile strength was, in general, higher than the ultimate strength in cross bending, the average increase being 5 per cent.

The average value of the Modulus of Elasticity in direct tension was also 5 per cent. higher, and varied between 120 and 170 times the tensile strength—the average being 150.

Plate No. 9 shows the relationship existing between the tensile strength and moisture percentage of various timbers.

STRENGTH IN END COMPRESSION.—Tests to ascertain the relative strength of columns of different lengths were made with specimens in which the ratio of length to minimum lateral dimensions ranged between 2/1 and 36/1, and the results are plotted diagramatically (*see* Plate No. 2) at 12 per cent. moisture.

From these tests the following data were obtained:—

(1.) Up to and including ratios of 12/1 the strength in end compression in all the timbers was fairly constant, and the specimens invariably failed in direct compression.

Under this condition the average strength varied between 11,600 and 8,450lbs. per square inch.

The Modulus of Elasticity in direct compression was in all cases below that obtained in the Cross Bending and Tensile Tests.

Diagram No. 12 on Plate No. 12 shows the relationship between the strength of the timber at different moisture percentages.

Karri, as in other tests, shows the greatest difference between the strength "green" and "dry," the former being 46 per cent. below the latter. The corresponding figures for the other timbers are—Yate 43 per cent., Blackbutt 40 per cent., Tuart 35 per cent., Jarrah 31 per cent., Red Gum 29 per cent., York Gum and Wandoo 23 per cent., Morrell 22 per cent., and Salmon Gum 21 per cent.

(2.) At a ratio of approximately 18/1 the strength in end compression falls to an extent of 2·9 per cent. in the case of Karri, and in that of Tuart 6·1 per cent. (these being the two limits). and the failure in 60 per cent. of the tests was by "side flexure."

The strength is quickly reduced as the "column ratio" is increased, and at a value of 36/1, which was the limit tested, the reduction in strength below that, at a 12/1 ratio, varied between 39 per cent. (Karri) and 47 per cent. (Wandoo).

It was found that the same percentages of reduction were closely followed at higher moisture values; hence, from the data given on Plates 2 and 12, the strength of any column at any "moisture percentage" can readily be computed

(3.) In all cases where the failure occurred in direct crushing, the fracture was of a sliding nature, shown on Plates Nos. 65 to 71, and this "sliding" invariably took place in the direction of the annual rings, as clearly shown on the group of specimens on Plate No 71.

In turned specimens, and in rectangular specimens wherever sliding occurred in a direction parallel to one of the sides of the specimen, the angle of sliding was always close to 45°.

In nearly all other cases the angle of sliding lay between 40° and 45° when measured directly in the direction of movement.

Where the specimens failed as "long columns," *i.e.*, by lateral flexure, in the majority of cases, failure occurred in the direction of the annual rings, rather than radially; but in many cases this was not so, apparently due to local inequalities in the specimens.

HARDNESS.—This was experimented upon by the measurement of both "static" and suddenly applied loads, and the former was found to more accurately represent the hardness of the material.

Where the load was suddenly applied, the "very moist" timbers generally gave higher results when they were partially seasoned than when dry, due probably to the elasticity of the specimens, the "cells" closing upon receiving the blow, and reopening immediately and before the depth of indentation could be measured—this being particularly noticeable with Karri and Red Gum.

For this reason, therefore, the static pressure required to produce a given penetration is the more accurate of the two methods, and as was to be expected, the "dry," "dense," "curly" grained timbers gave considerably higher results than those that are straight grained.

EXAMPLES ILLUSTRATING THE APPLICATION OF THE DIAGRAMS.—The following practical examples are given to illustrate the manner in which it is intended to apply the diagrams:—

(1.) To determine the central load that can with safety be carried upon a 12in. x 8in. Karri beam over a span of 10 feet, the timber being half "seasoned" (20 per cent. moisture).

From Plate 4 the ultimate extreme fibre stress of Karri when used as a beam of over 25 square inches, sectional area, is 14,200lbs. per square inch at 20 per cent. moisture.

Allowing for a factor of safety of 8, the allowable central load in lbs. is:—

$$\frac{2}{3} \times \frac{f.\,BD^2}{8.\,L} = \frac{2}{3} \times \frac{14{,}200 \times 8 \times 12 \times 12}{8 \times 10 \times 12} = 11{,}360 \text{ lbs., or approximately } \textit{five tons.}$$

Had "green" timber been used, the ultimate load per square inch would have been *11,300 lbs.*, and the allowable central load *four tons*; whereas with thoroughly seasoned timber these figures would have been 16,600 lbs. per square inch and *six tons* respectively.

In this case, therefore, the safe load upon the "seasoned" beam is 50 per cent. greater than upon the green timber.

(2.) To determine the deflection at the centre of a Blackbutt beam 12in. deep x 10in. in width, when carrying a uniformly distributed load of 2·6 tons over a span of 20 feet.

From Diagram No. 7, Plate 7, the modulus of elasticity of "green" Blackbutt when used in large beams is *1,450,000 lbs. per square inch*; therefore the deflection at the centre with a "green" beam would

$$= \frac{5.W.L^3}{384.E.I.} = \frac{5.W.L^3}{32.E.B.D^3} = \tfrac{1}{2} \text{ inch approximately.}$$

Had "dry" timber been used, the central deflection would have been slightly over $\frac{3}{8}$in., since the modulus of elasticity would have been *1,850,000 lbs. per sq. inch.* (From Diagram No. 7.)

(3.) To determine the safe load upon a 6in. x 6in. Tuart "strut," 6ft. in length, the timber being thoroughly seasoned.

The crushing strength of Tuart at 10 per cent. moisture is 11,250 lbs. per sq. inch from Table 1 and Plate 12, and hence the safe load, allowing for a "factor" of safety of 10, is equal to

$$\frac{11250 \times 36}{10} = 40{,}500 \text{ lbs., or approximately 18 tons.}$$

Had "green" timber been used, this "safe" load would have been reduced to 11 tons.

(4.) In the case of "long columns" the load has to be reduced as follows:—

"To determine the safe load upon a 6in. x 6in. Tuart strut 15ft. in length."

From Plate No. 2 it is seen that the strength of a column of Tuart in which the length is "thirty" times the breadth is 28·7 per cent. less than that of a similar short column.

Hence the safe loads on the 10ft. columns are 28·7 per cent. less than the figures above quoted for the 6ft. strut, *i.e.* are *13* and *8* tons for "seasoned" and "green" timber respectively.

(5.) At the points where a loaded beam is supported the material is subjected to a cross compressive stress, the intensity of which depends upon the "load" carried and the area of supports. Thus, in the case of the 12in. x 8in. Karri beam mentioned in the first example, the load upon each end in the case of the "dry" beam is three tons where the load remains central, or six tons where a moving or "live" load is to be expected.

The cross compression strength of Karri, when the load is distributed over the whole surface, is approximately 2,000 lbs. per square inch, at 3 per cent. deformation as shown in Table I.

Hence in the case of the live load, if a factor of safety of 10 is to be allowed, the area of support must not be less than

$$\frac{6 \times 2240 \times 10}{2000} \text{ i.e. } 67{\cdot}2 \text{ square inches,}$$

and since the breadth of beam is 8 inches, the length of "support" or overlap at each end should be at least $8\frac{1}{2}$ inches.

If the beam were of "green" timber, although the "safe" load would be reduced to four tons, yet the resistance to cross compression is correspondingly reduced, hence the same area of support would be required.

The preceding examples serve to illustrate the uses to which the "strength" diagrams can be put, and the only point upon which any difficulty may arise in "practice" is in the determination of "moisture percentage" from a knowledge of the time that has elapsed since the timber was felled.

Table No. 4 shows approximately the percentage of moisture that may be expected after various periods of "seasoning," both for large and small sizes, based upon the experience obtained with the timbers held in stock by the Government Departments for ultimate use in rolling-stock construction and other works.

Special Tests.—One of the most important uses of the hardwoods is as railway sleepers, for which some of the Western Australian timbers have been used for many years.

Certain special tests were therefore made to determine the relative suitability of the various timbers for this class of work, and also the physical state of the material after a varying number of years' service in the track.

In determining the value of a timber for use as a sleeper, three important items have to be considered:—

(1.) The durability of the timber, and its capacity for resisting dry rot and white ants, etc.

(2.) The hardness and toughness of the material to enable it to resist indentation by the rail without tendency to "split" or break up in service.

(3.) The requisite capacity for retaining the "dog spikes" in place.

Many specimens both of old and new timber were examined and tested to determine the above points, from which examination the following data were obtained:—

Durability.—Plates Nos. 32 to 41 are reproductions of photographs of sleepers drawn from the road for examination after a varying number of years' service, and without any special selection, and these, particularly in the case of the Jarrah and Wandoo, show the remarkable durability of the timbers.

The Jarrah and Wandoo sleepers shown on Plates Nos. 32, 33, 42, and 43 had been in service for over 19 years, and were still sound. Several of the Wandoo sleepers were cleaned, machine planed, and then tested in "Cross Bending," and the results obtained were only 6 per cent. below the average for thoroughly seasoned unused timber of the same dimensions, notwithstanding the fact that this timber had been in dirty gravel "ballast" for 19 years, and during that period had been exposed to moisture on the one face and two sides, and to the hot sun on the top face, and had also been subjected to all the wear and tear of railway traffic, and, further, in a district with a 20-inch rainfall in four months, the remainder of the year being very hot and dry.

There were no signs of dry rot upon any of these old Jarrah and Wandoo sleepers, which, prior to being tested, were sound enough to have continued in use for many years.

Plate No. 35 shows two Karri sleepers that had been in service in a damp position for 19 years, and although there were many signs of dry rot, yet they still retained their hold upon the dog spikes to a degree quite sufficient to render them safe in the road.

Plates Nos. 38 to 41 show Blackbutt and Red Gum sleepers after four years' service, and although this period is insufficient for test, yet, as the Plates show, the sleepers were absolutely sound and free from all signs of dry rot and white ant borings, although the country in which they were used is much infested with these pests.

Several of the Red Gum sleepers were machined and tested in cross bending, giving results from 3 per cent. to 5 per cent. below the average for unused seasoned timber.

As further examples of the durability of Western Australian timbers, the following results of examination and test may be quoted:—

(*a.*) Two Jarrah telegraph posts that were known to have been in use for a period of at least 20 years were tested in cross bending and end compression, etc., and gave results from 5 per cent. to 7 per cent. only below the average for unused seasoned timbers.

(*b.*) Two Wandoo slabs or face-cuts that had been in use in the decking of a road bridge for a period of 25 years were cut up and examined, and were found to be thoroughly sound throughout.

(*c.*) Four Jarrah posts that had been in use in building construction for eight years were cut up and tested, and the results obtained were up to the average for unused seasoned timber.

(*d.*) Two hewn square Jarrah piles were drawn from the Swan River for test, after having been in use for a period of 72 years, and were found to be sound, although completely saturated with salt water.

On Plate No. 27 is a reproduction from a photograph of one of these piles, which were both entirely free from signs of attack by the "marine borers."

(*e.*) Plate No. 27 also shows a section through a Jarrah pile after 18 years' service, showing holes bored by marine insects in the sap wood only, the body of the pile being thoroughly sound.

(*f.*) Plates Nos. 28 to 31 show Tuart, American Oak, and Teak bogie wagon bolsters after a varying number of years' service.

The Tuart bolsters were put into the trucks when green, 14 years ago, and are absolutely sound in every way, although in each case they were "heart wood," which is much more liable to crack and decay.

The bolt holes still showed the auger marks, and were free from any signs of corroded ironwork; the bolsters had not shrunk to any measurable extent, nor had the ironwork resting upon them cut into the timber, although bearing a very heavy load (10 tons when the truck is loaded).

A great number of these "bolsters" (all of the same age) are in service, none having been removed except for test, and all are apparently fit for at least 30 years' more work.

The American Oak bolsters represent the average condition of this timber after from five to eight years' service in the same class of wagons.

The Teak bolsters generally last from eight to ten years in the same service, by which time they are usually badly split and cracked, and have to be removed.

The uniformity of the results obtained with Tuart and Blackbutt under the various tests was very marked, there being considerably less range between the maximum and minimum values recorded with these than with any of the other timbers tested.

(*g.*) Blackbutt beams, 12in. x 4in. and 9in. x 5in., that had been in use for five years as "sole bars" in the heavy timber wagons used by the mill owners for conveying the logs to the mills, were cut and tested for cross bending, etc., and the results obtained were equal in every way to those given by unused seasoned timber.

This test is of particular interest, as although Blackbutt is not so strong as others of the Western Australian hardwoods, yet this timber is capable of successfully withstanding, without deterioration, many years of what is probably one of the most severe services to which timber can be put.

Throughout the tests of this timber the general soundness of the specimens was very noticeable, and owing to the large size of the trees, it undoubtedly ranks with Karri in the production of large beams of uniform quality throughout. It is also the lightest of the Western Australian hardwoods, which should render it of special utility where minimum weight is of importance, such as in rolling-stock construction, etc.

(*h.*) Two 12in. x 12in. Jarrah beams that had been in use as a slipway at Fremantle since the year 1873 were cut up and examined, and were found to be sound after having been 32 years under water.

(*i.*) One log of Red Gum and two logs of Tuart, that had been lying in damp ground for periods of 12, 15, and 12 years respectively, were cut up and tested, and found to be thoroughly sound throughout, and in nowise deteriorated.

(*j.*) Many examples of Karri beams that had been in service in wagon underframes for 19 years were examined and were found to be sound, particularly in those cases in which the timber had been partly seasoned before use.

The foregoing examples are sufficient to demonstrate the "soundness" and "durability" of the Western Australian timbers under various conditions.

Dry Rot, White Ants, etc.—Dry Rot is a disease to which "cut" timber is subject, and which destroys the "fibre," reducing it ultimately to a powder.

The disease occurs generally in timber used in damp and unventilated conditions, particularly when the timber has been used in the "green" state, and hence railway "sleepers" are very prone to develop it.

It appears to be infectious, and is probably due to, or at least assisted by the decomposition of the sap.

As it is known that certain of our timbers are more prone to develop this disease than others, a chemical examination of the saps was made, the results of which are given in Table No. 5.

Although this examination was of a comparatively elementary nature, yet certain facts were determined, which, to a certain extent, explained the different results that are obtained from the various timbers in practice.

Jarrah is well known to be practically free from all risks of dry rot, except under conditions extremely favourable to its development; and it is noticeable that 99½ per cent. of the sap of this timber is either moisture or volatile matter, and, further, that the acidity is very small.

It is to be expected, therefore, that decomposition will not take place, and hence its immunity to dry rot.

Wandoo, also, never develops this disease, and the examination of its sap, which is present in the timber to a comparatively small extent only, shows it to be of a thick viscous, gummy nature, of which only slightly over 50 per cent. is volatile.

It attacked metals to a lesser extent than any of the others tested, including Jarrah, notwithstanding its relatively high "acidity," this apparently being due to a coating of gum which always formed over the immersed metals.

When left standing and open to the air, no signs of decomposition were apparent, the sap being entirely unaffected. This timber might, therefore, be expected to be immune from dry rot, as is found to be the case in practice.

Karri, whilst in every other respect almost unequalled as a sleeper timber, is prone to develop dry rot if used when green in damp ground, and in the examination of its sap it was found to decompose when exposed to the air; and further, that it exercised a greater effect upon the metals immersed in it than was the case with any of the other saps.

With regard to the tests of Blackbutt and Red Gum, the results are not so conclusive, although in neither case was there any noticeable fermentation after standing; sufficient data are not yet available as to their immunity from dry rot when used as sleepers, as they have been in use for a comparatively short time only.

Of the sleepers examined, none as yet (after five years' service) show any sign of the disease.

Tuart has not been used to any great extent in situations where it would come in contact with the ground, and is, in fact, altogether too valuable a timber for such uses, but so far as is known it does not develop dry rot.

Jarrah and Wandoo, when sound and free from sap wood, are not attacked by white ants except in certain districts in the North-Western portion of the State, in which no known "cut" timber of sufficient size to provide sleepers is immune to attack; Blackbutt, Red Gum, Tuart, and Karri rarely suffer beyond the sap wood.

From the preceding remarks with regard to the development of dry rot it is seen that the presence of the sap is the chief source of trouble. This can be avoided in those timbers that are generally affected, either by using seasoned timber for sleepers, and preferably in some dry well-ventilated ballast, such as blue metal, under which conditions Karri will give excellent results; or by artificially removing the sap from the timber when green, and replacing it by some suitable substitute.

Such a process is now being experimented upon, which promises not only to render the timber practically immune to dry rot, but also to attacks from white ants, and should this process, which is both simple and cheap, prove successful as experiments to date promise, there can be no doubt that Karri will prove one of the most valuable "sleeper" timbers in the world.

HARDNESS AND TOUGHNESS.—An examination of the results of the hardness and spalling tests as given in Table No 1. affords sufficient proof that the Western Australian timbers possess the requisite degree of "hardness" to provide the best sleepers, and this is further demonstrated by the smallness of the indentation produced by the rail in the sleepers shown on Plates Nos. 32 to 43.

"HOLDING" POWER ON DOG SPIKES.—A considerable number of tests were made by means of the appliance shown on Plate No. 26 to determine the pull required to draw the spikes out of new and old sleepers, and the results of these tests are summarised in Table No. 6.

From this it is seen that, although there is a considerable falling off in the hold on the spike as the sleeper ages, yet after long periods in service, in some cases up to 20 years, the spikes were still sufficiently firm to hold the rail securely in place.

The results obtained from Wandoo were particularly striking in this respect, and are unequalled by any of the other well-known sleeper timbers of New South Wales and Queensland.

On Plate No. 7 a summary is given of the results of the above tests, also of those conducted by the Railway Department in Queensland, published by the Queensland Government in 1905 (*see* "The Merchantable Timber of Queensland" page 32), and it is to be noticed that in each of the "averages" Western Australian sleepers, although of greater age, give considerably higher results than were obtained in the Queensland tests.

GENERAL.

Before closing this report one item remains deserving of special mention, namely, the extraordinary strength of *Eucalyptus cornuta*, locally known as Yate.

This timber is as yet practically unknown, but is common to the South-West portion of the State, the trees usually attaining a diameter of from 2ft. 6in. to 3ft., and a maximum height of 100 feet.

As a "sawn" timber it is probably the strongest in the World, being far ahead of the rest of the Australian hardwoods in every variety of test, and in one tensile test with this timber a breaking load of 17½ tons per square inch was recorded, a value only 3½ tons below that usually specified for wrought iron of ordinary quality.

The results given are fair averages only, the timber being obtained as logs, which were wholly cut up and tested.

Its tough nature is well shown on Plates Nos. 49, 52, 57, 63, and 68, which are reproductions of photographs of tested specimens.

Many specimens of the less important timbers were received and tested, the results being included on Table No. 1.

Amongst these are the Banksias, Sheoaks, and Swamp Oak, which, whilst being fairly strong, are, owing to the nature of the grain, particularly suitable for ornamental work of every kind, and for the panelling of rail and tram coaches, for which purpose they are at present being used.

The following list enumerates the appendices, tables, plates, and diagrams that accompany this report:—

APPENDICES.

No. 1.—Description of Autographic Stress Strain Apparatus fitted to Testing Machine.

No. 2.—Description of Automatic Electric Beam Balancing Appliance, fitted to Testing Machine.

No. 3.—Description of appliance for automatically recording the Deformation in Cross Compression and Penetration Tests.

No. 4.—Details of Results of all Tests (not attached hereto).

SCHEDULES.

No. 1 (folding plate at end of report).—Summary of Results of Tests of Western Australian and other Hardwoods.

No. 2.—Data *re* Timber received for Test.

No. 3.—Summary of results of Cross Bending Tests for Beams of various sizes.

No. 4.—Table showing relationship between Moisture percentages and Seasoning for Timbers of various sizes.

No. 5.—Summary of results of Chemical Tests of "Saps."

No. 6.—Particulars of results of Tests to determine the holding power of Dog Spikes in Sleepers.

No. 7.—Summary of results of Tests with "Dog Spikes," and comparison with those obtained with other hardwoods.

DIAGRAMS.

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No. 2, Plate 2.—Ultimate load per square inch for columns at 12 per cent. moisture, showing the resultant reduction in strength as the ratio of length to breadth is increased.

Nos. 3 to 8, Plates 3 to 8.—Showing the relationship between the Strength, "Elasticity," and "Moisture Condition" of Jarrah, Karri, Tuart, Wandoo, Blackbutt, and Red Gum Beams of various sizes.

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No. 12, Plate 12.—Average strength of Western Australian Timbers in end compression at varying moisture percentages.

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APPENDIX No. 1.

AUTOGRAPHIC STRESS STRAIN APPARATUS

(*See* Plates Nos. 15 and 19).

This apparatus, shown diagramatically on Plate No. 19 and devised by the writer, was fitted to the 40-ton testing machine to enable records to be taken of the cross bending, tension, and other tests.

Its operation hardly requires explanation, but may be stated briefly as follows:—

Two levers are pivoted on a rigid frame at the points C1 and C2, their lower edges provided with knife edges pressing against clips attached to the specimen at the gauge length, and their top ends carrying aluminium wheels P and Q, six inches in diameter, at the points C3 and C4 respectively.

As the specimen stretches, these points C3 and C4 approach one another, moving a distance equal to twice the extension of the specimen.

A very light steel chain is attached to the point S, which forms one arm of a lever pivoted at the point C5. This chain is led round the wheel P, back round Q, thence over the wheel R, which is carried by the fixed framing, and from there down to a small drum upon which it is wound.

As the specimen stretches, the point S, therefore, moves a distance equal to four times the elongation.

Pivoted vertically in the frame is the diagram drum, which will take a sheet 24 inches square, and in front are two bars pivoted in a vertical plane, and carrying two pens, the "carriages" of which run in grooves in the bar. The points of these pens lie in the same vertical line, and they are suspended by silk cords from the pivoted beams above, which are so proportioned that the movement of one pen (which is always ahead of the second) is 200 times the "stretch" of the specimen, and that of the other 20 times the elongation.

The top beam carrying the 1/200 pen automatically throws itself out of gear when the pen reaches the bottom of the sheet, which generally occurs after the elastic limit is passed.

In cross-bending tests, the top beam is not used, and where excessive deformation is expected, the chain, after passing round the wheel Q, is brought down to an adjusting drum of the lever, carrying that wheel, thus reducing the movement of the point S to twice the extension of the specimen.

The diagram drum is revolved through reducing gear by means of a steel wire from the Jockey Weight on the weighing beam of the machine, and since this beam is always kept in perfect balance by means of the automatic gear described in Appendix 2, the stress-strain diagram obtained is accurate. The reducing gear above referred to is varied in "ratio" to suit the expected maximum load, so as to obtain as open a load scale as possible.

Some thousands of tests have been made by this appliance, which has operated very successfully.

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APPENDIX No. 2.

DESCRIPTION OF AUTOMATIC BEAM-BALANCING APPLIANCE FITTED TO 40-TON TESTING MACHINE

(*See* Plates Nos. 20, 20a, 21, and 22).

This appliance, which was devised by the writer and fitted to the 40-ton Buckton Testing Machine, automatically maintains the Weighing Beam in "balance" whether under a rising or falling load, by operating the Jockey Weight at the required speed. It practically eliminates the "personal" element in the operation of the machine, and during the past eight months has been used for over nine thousand tests with most satisfactory results.

The apparatus consists essentially of two duplicate shunt wound ¼-Horse Power Lundell Motors, working at 110 volts and nominally running at 1,300 revolutions per minute. These are mounted in line on a common bed plate, and the armature of each is attached to a cast-iron bevel friction wheel, each of which gears with two rubber-faced bevel wheels, which are in turn carried on a frame that revolves freely about the armature spindles.

The whole gear forms an "epicyclic train" exactly similar to that used in many Transmission Dynamometers. This gear is plainly shown on Plates 20 and 21.

The motors are nominally set to run in opposite directions, and when so running at equal speeds the frame carrying the rubber-faced bevel wheels remains stationary. Any difference in speed is accompanied by a corresponding movement of the wheel frame, which will revolve in the same direction as that in which the fastest motor is running, and at a speed equal to half the difference in speed between the two motors.

The movement of the "frame" is communicated by means of belt and gearing to the shaft that operates the Jockey Weight hereinafter described.

The speed of the two motors is varied by means of liquid resistances in both the main and field circuits, and these resistances are operated automatically by the "balance" of the beam.

Referring first to Plate No. 20:—

A. is the weighing beam of the testing machine, and P. is the pointer operated thereby, which, when the beam is balanced, stands vertically, but moves to either one side or the other as the beam rises or falls.

S. is the shaft that operates the Jockey Weight by means of the usual hand wheel, and which has been extended to carry the gear for transmitting the motion from the motors, this being clearly shown in the top illustration on Plate No. 21.

Ls. and Lf. are the liquid resistances which are in "series" with the main and field circuits respectively.

These resistances each consist of two hollow cones fixed in a glass vessel containing "acidulated" water, as shown, and between them in each case is a double cone suspended from one end of a light pivoted beam which, in turn, is connected to the pointer P.

As the weighing beam of the testing machine rises or falls so the cones in the liquid resistance are raised and lowered. Thus, if the "nose" of the "beam" rises, requiring the Jockey Weight to be moved outward more rapidly, the pointer P. moves the beam of the liquid resistances, thus raising one cone and lowering the other. This increases the resistance in the armature circuit of one motor and simultaneously cuts it out of the circuit of the other. It also cuts resistance out of the field circuit of this first motor and

puts resistance into that of the second. Consequently one motor is much accelerated and the other retarded, and the frame revolves at a corresponding speed in the direction of the fast motor, thus moving the Jockey Weight.

The position of the cones in the resistance cells can also be regulated by hand without interfering with the automatic connection to the weighing beam. Any desired lead can, therefore, be given to the motors on a steadily rising or falling load, thus rendering it possible to maintain the beam in perfect balance with the pointer P at mid position.

The foregoing briefly describes the principle upon which the appliance is operated, but many refinements were added to make the scheme a practical success.

The operation of the finished apparatus is as follows (*see* Plates 20 and 20a) :—

M.S. is the main double pole switch controlling the supply from the mains.

R. is a starting rheostat which, when moved over, simultaneously starts both motors. This rheostat is of ordinary pattern, fitted with minimum release, the coil for which is shown at Rc. This coil is not in series with field windings, as is usually the case, but is in series with a switch M which controls the whole circuit, an incandescent lamp L, a switch BS, and a magnetic clutch coil K, the functions of which are as follows:—The lamp, which is mounted in a prominent position on the machine, is used to cut down the voltage and also show when the current is passing. The magnetic clutch coil K controls the connection between the motors and the Jockey Weight, by drawing two "fine-tooth" ($\frac{1}{16}$in.) gear wheels together when current is passing and allowing them to fall apart when the circuit is broken. This gear is clearly shown on Plate 21. The switch BS is controlled by the weighing beam of the machine, which, when it falls or rises to its extreme position (as happens when the specimen fails, and when the weight is run right back respectively), breaks the circuit, thus instantly throwing the toothed wheels out of gear and simultaneously freeing the arm of the "starter," which flies back and allows the motors to come to rest.

The necessity for the clutch lies in the fact that the motor cannot be stopped instantly, and hence, if not thrown out of gear, the Jockey Weight would be moved from the position it held at the "breaking point," thus giving a wrong record.

An auxiliary switch (Z), when closed, short circuits the magnetic clutch coil, thus allowing the motors to be re-started, if so desired, without operating the Jockey Weight.

The switch C, shown on Plates 20 and 20a, controls the current passing to the motor through the liquid resistance. This switch, as shown in detail, has three positions, which operate as follows:—

When in a vertical position the current is so directed that the motors run in opposite directions, as ordinarily required when the test is proceeding.

When in that position, the switches X and Y are in the armature circuit of the two motors respectively, and if either switch is opened that motor stops, and the wheel frame then runs at half the speed of one motor, moving the jockey weight at a corresponding speed. Upon closing the switch the motor starts up and the automatic control again comes into operation. This makes it possible to meet sudden fluctuations in the load which sometimes occur during a test, due either to local inequalities in the specimen or to a sudden opening or closing of the hydraulic valves which govern the water supply to the main "ram."

In testing timber, inequalities in the specimen frequently cause the beam to drop suddenly, which would stop the motor by breaking the controlling circuit at the switch BS, and thus cause considerable delay. This is avoided by means of the switch W, which can be so set as to short-circuit BS. After a test is complete, and the motors are stopped, the controller handle is moved over to position 1, in which position the liquid resistances are short-circuited and both motors run in the same direction, thus causing the wheel frame to revolve at the same speed in that direction. This returns the jockey weight at "quick" speed to zero position on the beam, at which point the tail of the beam drops and breaks the "control" circuit at BS, thereby stopping the motor and preventing overwinding. The machine is then ready for the next test.

Sometimes it is required to run the jockey weight out rapidly, which is done by placing the controller handle in position 2. This causes both motors to run in the opposite direction to that in which they were running in position 1.

In some classes of tests, particularly in compression, it is desirable to apply the load at a constant rate, which is done by setting the liquid resistance in a fixed position to give the required speed and then adjusting the hydraulic valve to suit.

The arrangement of the controller connections can readily be followed on Plate 20A. It may be mentioned that the friction required to transmit the power in the epicyclic train of wheels is supplied by means of springs, and the thrust in all four bevel wheels is taken on "ball bearings."

The rubber faces on two wheels required replacing after 7,000 tests had been completed. Whilst this apparatus has successfully withstood a very severe test during the past eight months, there is no doubt that the details can be considerably improved, it having been fitted up and put into operation entirely without experiment. The principle upon which it operates however, has proved successful in every way, and a very much greater degree of accuracy was obtained when stress strain diagrams were taken.

APPENDIX No. 3.

DESCRIPTION OF "AUTOMATIC" DEFORMATION RECORDER FOR CROSS COMPRESSION AND PENETRATION TESTS.

(*See* Plates Nos. 17 and 18.)

This appliance is a modification of the apparatus devised by Professor J. B. Johnson for the "cross compression" tests of timber.

Referring to Plate No. 17, the contact pin P is carried by a hinged steel arm, which is adjustable in length. When fully extended this arm is 30 inches long, but can be reduced by equal increments of 0·9 of an inch, *i.e.*, by 3 per cent. of its initial length each step.

It is held in each position by the spring lock L.

The point of the contact pin P lies exactly in the centre line of the arm and hinge F, and this hinge F lies wholly in the plane of, and is carried by an arm attached to the back table of the machine which receives the specimen.

The adjustable arm is moved by means of the screw S, and can be clamped in any position relative to the fixed arm by means of the clamp C.

The contact pin P is electrically insulated from the sliding portion of the hinged arm, and a spring is fitted to the "point," which allows it to be pushed backward in the event of any pressure coming upon it, thus preventing any distortion of the apparatus.

An insulated wire is led from the platinum-pointed contact pin P through a battery of two Leclanche cells, an electric bell, and a switch, from which it is led back to the "movable" or "front" compression table of the testing machine.

The operation of the apparatus is as follows:—

A specimen is placed against the back table and the front movable table is brought up to it, just holding it in place. The electric switch being closed, the adjustable arm at its "extreme" length is swung round upon the hinge F by means of the screw S until the contact pin P just touches the movable table, thus completing the electrical circuit and ringing the bell. The arm is then clamped by the nut C. If a 3% deformation is to be recorded the adjustable arm is shortened by 0·9 *i.e.*, by 3% of its length, thus bringing the point of the pin P 3% nearer to the back table of the machine.

The load is then applied to the specimen, and as soon as its thickness is reduced by 3% the circuit is again completed, and the bell again rings.

By sliding the arm back a further distance, other percentages of deformation can be obtained.

The apparatus will take specimens of any thickness between 6 inches and $1\frac{1}{4}$ inches, and the fact that no calculation of any sort is necessary to obtain the required percentage of deformation results in greater accuracy and still greater saving in time.

The same appliance, slightly modified, was used for recording $\frac{1}{20}$ inch indentations in the hardness tests, as follows:—

The arm was clamped in a fixed position, such that when fully extended (to 30 inches) the normal distance between the point of the contact pin P and the "back table" was $1\frac{2}{3}$ inch. Hence when the sliding arm was reduced in length by 3% the normal distance between point of pin P and table was decreased by 3% of $1\frac{2}{3}$ inch, *i.e.*, by one twentieth of an inch.

In using the appliance, the specimen was placed in the machine, and the moving table with the penetration die attached was brought up to the specimen, just holding it in place.

An adjustable steel table T carried by the movable head of the machine, was then screwed out till it just touched the pin P and rang the bell. The sliding arm was then shortened by 3%, and when the table again touched the point, as evidenced by the bell, a penetration of the required amount had been reached.

Throughout the tests it was found that a quarter of a minute afforded ample time to set the apparatus for each specimen.

WESTERN AUSTRALIAN TIMBER TESTS, 1906. [Schedule No. 2.]

PARTICULARS OF TIMBER RECEIVED FOR TESTING.

Name of Timber.	Sample Nos.	Nature of Specimen.	Bulk Size.	Obtained from.	Date Received.	Locality grown.	Age when tested.	Remarks.
Jarrah	66 to 73	Hewn sleepers ...	8/7ft. x 9in. x 4½in.	Railway Contract Supply, Way and Works Branch	10-11-05	...	Felled within 3 months	Unused sleepers
Do.	74 to 77	do. ...	4/7ft. x 9in. x 4½in.	do. ...	10-11-05	...	1 year	do.
Do.	78 to 81	Sawn beams ...	4/15ft. x 12in. x 6in.	do. ...	10-11-05	...	Felled within 3 months	
Do.	82 to 85	Sawn posts ...	4/10ft. x 7in. x 7in.	do. ...	10-11-05	...	8 years	Old used posts
Do.	135 to 138	Sawn beams ...	4/14ft. x 12in. x 7in.	do. ...	15-11-05	...	Felled within 3 months	
Do.	147 to 148	Hewn square piles	... ...	Fremantle Harbour Works	20-11-05	...	70 years	Drawn after 70 years in Swan River
Do.	149 to 153	Sawn beams ...	5/13ft. 6in. x 16½in. x 7in.	do. ...	20-11-05	...	5 years	
Do.	154 and 155	do. ...	2/13ft. 3in. x 10in. x 9in.	do. ...	20-11-05	...	5 years	
Do.	156 and 157	Hewn beams ...	2/14ft. 3in. x 12in. x 12in.	do. ...	20-11-05	...	32 years	32 years under sea water. Used in slip, Swan River
Do.	158 and 159	Sawn beams ...	2/9ft. 3in. x 12in. x 7in.	do. ...	20-11-05	...	10 years	Used previously in construction
Do.	160	do. ...	8ft. x 12in. x 12in.	do. ...	20-11-05	...	10 years	do. do.
Do.	01, 03, 04	Hewn sleepers ...	3/7ft. x 8in. x 4in.	Railway Contract Supply, Way and Works Branch	Nov., 1905	...	7 years	Old used sleepers
Do.	02, 05, 06	do. ...	3/7ft. x 8in. x 4in.	do. ...	Nov., 1905	...	Felled within 3 months	New unused sleepers
Do.	161	Dressed specimens	8/4ft. 6in. x 2in. x 2in.	Millar's Karri & Jarrah Co...	Sept. 1901	S.W. District ...	4¼ years	
Do	162	do. ...	8/4ft. 6in. 2in. x 2in.	do. ...	Sept. 1901	Do. ...	4¼ years	
Do.	171 to 210	Sawn sleepers ...	40/7ft. x 8in. x 4in.	C.E.E.L. Branch ...	24-11-05	Do. ...	13 years	13 years in "road" at Mundijong S.W. Railway
Do.	361 to 365	do. ...	5/7ft. x 8in. x 4in.	do. ...	6-12-05	...	11 years	11 years in "road," Great Southern Railway
Do.	366	Sawn Telegraph Pole	20ft. x 6in. x 6in.	do. ...	20-2-06	...	20 years	Used previously in Telegraph Line
Do.	457	1 board	4ft. x 10in. x 1in.	Mr. Guppy, Guildford ...	10-11-05	Canning Jarrah Mill	...	Curly jarrah, used for samples only
Do.	463	Sawn Telegraph Pole	20ft. x 6in. x 6in.	C.E.E.L. Branch	20-2-06	...	20 years	Used previously in Telegraph Line
Do.	475 to 480	Hewn sleepers ...	6/7ft. x 9in. x 4½in.	Railway Contract Supply, Way and Works Branch	9-4-06	...	1 year	Unused sleepers
Do.	535 to 542	do. ...	8/7ft. x 9in. x 4in.	do ...	2-5-06	...	1 year	Unused sleepers
Do.	547 to 549	do. ...	/7ft. x 9½in. x 4½in.	do ...	6-5-06	...	Felled within 3 months	Unused sleepers
Do.	551 and 552	Sawn beams ...	2/5ft. x 8in. x 8in.	Railway Contract Supply, C.M.E. Branch	1-6-06	...	Felled within 3 months	Unused timber
Do.	554 to 559	Hewn sleepers ...	6/7ft. x 8in. x 4in. ...	Railway Contract Supply, Way and Works Branch	8-6-06	...	10 years in road	
Do.	563	Sawn beam ...	1/6ft. x 8in. x 8in. ...	Railway Contract Supply, C.M.E. Branch	10-6-06	...	Felled within 3 months	Unused timber
Karri	1 to 6	Sawn beams ...	6/10ft. x 12in. x 3in. ...	do. do ...	18-9-05	Karridale ...	do.	
Do.	7 to 12	do. ...	6/12ft. x 9in. x 3¾in. ...	do. do. ...	18-9-05	do. ...	8 months	
Do.	19 to 52	do. ...	34/10ft. and 12ft. x 2½in. x 2¼in.	Railway Contract Supply, C.R.S. Branch	18-9-05	do. ...	10 years	
Do.	86 to 89	do. ...	4/15ft. x 9in. x 3in. ...	Railway Contract Supply, Way and Works Branch	10-11-05	do. ...		
Do.	102 to 109	do. ...	8/15ft. x 9½in. x 4½in. ...	Railway Contract Supply, C.M.E. Branch	30-11-05	do. ...	3 years	
Do.	118 to 129	do. ...	12/12ft. x 9½in. x 3¾in. ...	do. do. ...	30-11-05	do. ...	8 years	

PARTICULARS OF TIMBER RECEIVED FOR TESTING—*continued.*

Name of Timber.	Sample Nos.	Nature of Specimen.	Bulk size.	Obtained from.	Date received.	Locality grown.	Age when tested.	Remarks.
Karri	163	Dressed specimens	12/4ft. 6in. x 2in. x 2in. ...	Millar's Karri & Jarrah Co.	Sept , 1901	Karridale ...	4¼ years	
Do.	164	do. ...	9/4ft. 6in. x 2in. x 2in. ...	do. do. ...	Sept., 1901	do. ...	4¼ years	
Do.	165	do. ...	11/3ft. 3in. x 2in. x 2in. ...	do. do. ...	Sept., 1901	do. ...	4¼ years	
Do.	346 to 360	Sawn sleepers ...	15/7ft. x 8in. x 4in.	C.E.E.L. Branch	18-11-05	Denmark, G.S.R.	19 years	19 years in road, G.S. Railway
Do.	481 to 484	do. ...	4/7ft. x 8in. x 4in.	Railway Contract Supply, C.M.E. Branch	9-4-06	Karridale ...	Felled within 3 months	New unused sleepers
Do.	487	Sawn timber ...	6ft. x 8in. x 4in.	do. ...	27-4-06	do. ...	do. do.	
Do.	488	do. ...	5ft. x 8in. x 4in.	do. ...	27-4-06	do. ...	do. do.	
Do.	489 to 498	Sawn beams ...	10/12ft. x 9in. x 4in.	do. ...	1-5-06	do. ...	3 years	
Do.	511 to 534	do. ...	24/6ft. x 5¼in. x 3¾in.	do. ...	1-5-06	do. ...	Felled within 3 months	
Do.	543 and 544	do. ...	2/15ft. x 9in. x 4in.	do. ...	6-5-06	do. ...	do. do. ...	Unused beam
Do.	560 and 562	do. ...	2/6ft. x 12in. x 8in.	do. ...	10-6-06	do. ...	do. do.	
Tuart	13 and 14	do. ...	2/10ft. x 12in. x 3in.	do. ...	18-9-05	Capel, S.W.R. ...	do. do.	
Do.	54	Sawn beam ...	13ft. x 12¼in. x 3¾in.	do. ...	3-11-05	do. ...	do. do.	
Do.	55 to 58	Sawn beams ...	4/10ft. x 12¼in. x 3¾in.	do. ...	3-11-05	do. ...	do. do.	
Do.	110 to 117	do. ...	8/15ft. x 10¼in. x 4¼in.	do. ...	30-11-05	do. ...	do. do.	
Do.	130 to 133	do. ...	4/15ft. x 10¼in. x 4¼in.	do. ...	30-11-05	do. ...	do. do.	
Do.	166 and 167	Dressed specimens	18/4ft. 6in. x 2in. x 2in.	Millar's Karri & Jarrah Co.	Sept., 1901	South Western District	4¼ years	
Do.	168	do. ...	12/5ft. x 4in. x 4in.	do. ...	Sept., 1901	do. ...	do.	
Do.	170	do. ...	12/5ft. x 2in. x 2in.	do. ...	Sept., 1901	do. ...	do.	
Do.	222	Sawn headstock ...	7ft. 6in. x 11in. x 4in.	Railway Contract Supply, C.M.E. Branch	10-11-05	do. ...	11 years	Used in truck for 11 years
Do.	231	Sawn Bolster ...	... ...	do. ...	7-11-05	S.W. District ...	12 years	Used as bolster in timber truck for 12 years
Do.	237	1 log	16ft. long, 6ft. 3in. girth...	Purchased through C.R.S. Branch	5-12-05	Capel, S.W.R. ...	15 years	Cut 15 years. Lying on ground.
Do.	238	do.	15ft. 9in. long, 7ft. 4in. girth	do.	5-12-05	do. ..	5 years	
Do.	295	do.	9ft. 10in. long, 4ft. 1in. girth	C.E.E.L. Branch	4-12-05	Ludlow, S.W.R.	12 years	
Do.	499 to 504	Sawn beams ...	6/15ft. x 10in. x 4in.	Railway Contract Supply, C.M.E. Branch	2-5-06	Capel, S.W.R. ...	Felled within 3 months	
Do.	545 and 546	do. ...	2/15ft. x 9in. x 4in.	do.	6-5-06	do. ...	do. do.	
Do.	550 and 553	do. ...	2/3ft. x 12¼in. x 4¼in.	do.	1-6-06	do. ...	do. do.	
Do.	561	Sawn beam ...	1/12ft. x 11in. x 3¼in.	do.	10-6-06	do. ...	do. do.	
Do.	564	do. ...	1/12ft. x 12in. x 4in.	do.	10-6-06	Ludlow, S.W.R.	5 years	
Wandoo ...	134	1 log, hewn square	15ft. x 23in. x 20in.	C.E.E.L. Branch	1-11-05	Wooroloo ...	1 year	
Do. ...	143	1 log	5ft. long, 3ft. 8in. girth	do.	20-11-05	Newcastle District	Felled within 3 months	
Do.	144 to 146	Hewn sleepers ...	3/7ft. x 8in. x 4in.	do.	20-11-05	do. ...	18 years	18 years in "road" on Newcastle line
Do.	220 to 221	Slabs or face cuts...	2/5ft. x 1ft. 6in. wide	Obtained through C.R.S. Branch	29-11-05	Near Serpentine, S.W. Railway	25 years	25 years in use as bridge decking
Do.	274 to 288	Hewn sleepers ...	15/7ft. x 8in. x 4in.	C.E.E.L. Branch	13-12-05	Newcastle District	18 years	18 years in "road" on Newcastle line
Do.	290	1 log	11ft. 8in. long, 6ft. 9in. girth	Purchased through C.R.S. Branch	13-12-05	63m. 27c. on Newcastle Railway	19 years	Cut 19 years
Do.	291	do.	9ft. 7in. long, 9ft. 5in. girth	do. ...	13-12-05	66m. 60c. on Newcastle Railway	19 years	Dead 19 years. Cut 3/12/05

PARTICULARS OF TIMBER RECEIVED FOR TESTING—*continued.*

Name of Timber.	Sample Nos.	Nature of Specimen.	Bulk Size.	Obtained from	Date received.	Locality grown.	Age when Tested.	Remarks.
Wandoo ...	292	1 log	15ft. long, 6ft. girth	Purchased through C.R.S. Branch	13-12-05	65m. 48c. on Newcastle Railway	Felled within 3 months	
Do.	293	do.	15ft. 4in. long, 5ft. 7in. girth	do. ...	13-12-05	62m. 74c. ...	1 year	
Do.	301 to 315	Hewn sleepers ...	15/7ft. x 8in. x 4in.	C.E.E.L. Branch	19-12-05	...	8 years	8 years in "road" on Cue railway
Do.	469 to 474	Sawn timber ...	6/6ft. x 3in. x 3in.	Hudson & Richie, Fremantle	11-4-06	Wooroloo, Eastern Railway	9 months	
Do.	505 to 506	Dressed specimens	2/7ft. 6in. x 10in. x 4in.	do. ...	1-5-06	do. ...	9 months	
Do.	507 to 510	do. ...	4/6ft. x 6ft. x 4in.	do. ...	1-5-06	do. ...	9 months	
Blackbutt ...	90 to 101	Sawn Timber ...	12/11ft. x 4in. x 3in. ...	Railway Contract Supply, Way and Works Branch	10-11-1905	S.W. District ...	8 months	
Do.	211	do. ...	7ft. x 12in. x 4in. ...	Millar's Karri and Jarrah Co.	28-11-1905	Yarloop S.W. Railway	4 years	Headstock 4 years in log truck
Do.	212	do. ...	7ft. x 9in. x 3in. ...	do. do. ...	28-11-1905	do. ...	2½ years	
Do.	213	do. ...	7ft. x 12in. x 5in. ...	do. do. ...	28-11-1905	do. ...	4½ years	
Do.	214	do. ...	8ft. x 10in. x 4½in. ...	do. do. ...	28-11-1905	do. ...	20 months	
Do.	215	do. ...	12ft. x 9in. x 5in. ...	do. do. ...	28-11-1905	do. ...	9 months	
Do.	216	do. ...	11ft. x 9in. x 5in. ...	do. do. ...	28-11-1905	do. ...	4¾ years	Used in log truck sole bar for 4¾ years
Do.	217	do. ..	7ft. x 10in. x 3½in. ...	do. do. ...	28-11-1905	do. ...	20 months	
Do.	235	1 log	15ft. 4in. long, 7ft. 10in. girth	Purchased through C.R.S. Branch	5-12-1905	Kirrup, Bridgetown Railway	Felled within 3 months	
Do.	236	do.	15ft. 2in. long, 8ft. 6in. girth	do. do. ...	5-12-1905	do. ...	8 years	
Do.	250 to 261	Sawn sleepers ...	12/7ft. x 8½in. x 4in.	C.E.E.L. Branch	7-12-05	S.W. District ...	4 years	4 years in Northam-Goomalling Railway
Do.	262	Sawn timber ...	6ft. x 10in. x 4½in.	Millar's Karri and Jarrah Co.	7-12-05	Yarloop S.W. Railway	5 years	
Do.	263	do. ...	6ft. 6in. x 11in. x 4½in.	do. ...	7-12-05	do. ...	5 years	
Do.	264 and 265	do. ...	2/6ft. x 9in. x 5in.	do. ...	7-12-05	do. ...	5 years	
Do.	266	do. ...	6ft. x 8½in. x 5in.	do. ...	7-12-05	do. ...	5 years	
Do.	267	do. ...	6ft. x 8¾in. x 5in.	do. ...	7-12-05	do. ...	5 years	
Do.	271 to 273	Sawn sleepers ...	3/7ft. x 8½in. x 4in.	C.E.E.L. Branch	7-12-05	S.W. District ...	4 years	4 years in "road" Northam-Goomalling Railway
Do.	331 to 345	do. ...	15/7ft. x 8in. x 4in.	do. ...	19-12-05	do. ...	4 years	4 years in "road" Nannine Railway
Do.	406 to 422	Sawn beams ...	17/13ft. x 12½in. x 4½in.	Millar's Karri and Jarrah Co.	6-2-06	Yarloop S.W. Railway	Felled within 3 months	
Do.	423 to 426	do. ...	4/13ft. x 12½in. x 4½in.	do. ...	6-2-06	do. ...	1 year	
Do.	427 to 441	Sawn timber ...	15/6ft. x 4½in. x 4½in.	do. ...	6-2-06	do. ...	1 year	
Do.	442 to 452	do. ...	11/6ft. x 4½in. x 4½in.	do. ...	6-2-06	do. ...	Felled within 3 months	
Red Gum ...	233	1 log	15ft. 4in. long, 7ft. 8in. girth	Purchased through C.R.S. Branch	5-12-05	Kirrup, Bridgetown Railway	8 years	
Do. ...	234	do.	15ft. 6in. long, 7ft. 1in. girth	do.	5-12-05	do. ...	Felled within 3 months	
Do. ...	240 to 249	Sawn sleepers ...	10/7ft. x 8½in. x 4in. ...	C.E.E.L. Branch	7-12-05	S.W. Railway ...	4 years	4 years in "road," Northam-Goomalling Railway
Do. ...	316 to 330	do.	15/7ft. x 8½in. x 4in. ...	do.	19-12-05	do. ...	4 years	4 years in "road," Nannine Railway
Do. ...	367 to 380	Sawn beams ...	14/13ft. x 12½in. x 4½in. ...	Millar's Karri and Jarrah Co.	6-2-06	Yarloop, S.W. Railway	Felled within 3 months	
Do. ...	381 to 405	do.	25/6ft. x 4½in. x 4½in. ...	do.	6-2-06	do. ...	do.	

PARTICULARS OF TIMBER RECEIVED FOR TESTING—*continued.*

Name of Timber.	Sample Nos.	Nature of Specimen.	Bulk Size.	Obtained from	Date Received.	Locality grown.	Age when tested.	Remarks.
Yate	239	1 log	16ft. 2in. long, 4ft. 9in. girth	Purchased through C.R.S. Branch	5-12-05	Capel, Bridgetown Railway	Felled within 3 months	
Do. ...	460	do.	15ft. 6in. long, 6ft. 1in. girth	do.	9-3-06	Mt. Barker, G.S. Railway	do.	
Do. ...	461	do.	8ft. 3in. long., 5ft. 10in. girth	do.	9-3-06	do. ...	3 years	3 years felled
York Gum ...	139	do.	5ft. 11in. long, 4ft. girth ...	C.E.E.L. Branch	20-11-05	Northam District	Felled within 3 months	
Do. ...	140	do.	6ft. long, 3ft. 2in. girth ...	do. ...	20-11-05	do. ...	3 years	
Do. ...	141	do.	5ft. 2¼in. long, 4ft. 7in. girth	do. ...	20-11-05	Newcastle District	4 years	63¼-miles on Newcastle Line (cut).
Do. ...	142	do.	6ft. long, 3ft. 3in. girth ...	do. ...	20-11-05	do. ...	Felled within 3 months	63¾-miles on Newcastle Line (cut)
Do. ...	223	do.	5ft. 6in. long, 3ft. 2in. girth	Millar's Karri and Jarrah Co.	28-11-05	Cut near Northam	do.	
Do. ...	224	do.	7ft. long, 2ft. 10in. girth	do. ...	28-11-05	do. ...	Over 3 years.	
Do. ...	225	do.	3ft. 4in. long, 3ft. 2in. girth	do. ...	28-11-05	do. ...	Felled within 3 months	
Do. ...	226	do.	8ft. long, 2ft. 3in. girth ...	do. ...	28-11-05	do. ...	do.	
Do. ...	227	do.	5ft. 6in. long, 2ft. 3in. girth	do. ...	28-11-05	do. ...	do.	
Do. ...	289	do.	10ft. 5in. long, 6ft. 4in. girth	Chief Engineer Existing Lines Branch	13-12-05	Newcastle District	do.	Cut 63 miles 6 chains on Newcastle Line
Do. ...	294	do.	11ft. 5in. long, 5ft. 7in. girth	do. ...	13-12-05	do. ...	do.	Cut 63 miles 60 chains on Newcastle Line
Do. ...	466	do.	11ft. 10in. long, 3ft. girth	Purchased through C.R.S. Branch	3-4-06	Newcastle District	Felled within 3 months	
Do. ...	467	do.	16ft. long, 3ft. 9in. girth...	do. do. ...	3-4-06	do. ...	do.	
Salmon Gum ...	297	do.	12ft. 5in. long, 3ft. 3in. girth	Midland Railway Company	18-12-05	Near Moora, Midland Railway	do.	
Do. ...	298	do.	12ft. 11in. long, 3ft. 1in. girth	do. ...	18-12-05	do. ...	Over 2 years	
Morrell ...	299	do.	12ft. 5in. long, 2ft. 7in. girth	do. ...	18-12-05	do. ...	Felled within 3 months	
Do. ...	300	do.	12ft. 5in. long, 2ft. 9in. girth	do. ...	18-12-05	do. ...	Over 2 years	
Do. ...	465	do.	11ft. 7in. long, 4ft. 9in. girth	Purchased through C.R.S. Branch	3-4-06	14 miles N.E. of Newcastle	Felled within 3 months	
Sheoak ...	269	do.	6ft. long, 4ft. 4in. girth ...	do. ...	12-12-05	Serpentine, S.W.R.	6 months	
Do. ...	455	do.	6ft. 7in. long, 4ft. 11in. girth	do. ...	26-1-06	do. ...	5 months	
Banksia ...	232	Hewn baulks ...	2/5ft. x 20in. x 10in. ...	do. ...	30-11-05	Mullalyup-Bridgetown Railway	7 months	
Do. ...	296	do.	1/10in. x 22½in. x 10in. ...	do. ...	30-11-05	do. ...	do.	
Jam Wood ...	219	1 log	6ft. long, 2ft. 4in. girth ...	do. ...	29-11-05	Kelmscott, S.W.R.	do.	
Do. ...	453	1 slab, hewn ...	6ft. long x 5½in. x 3in. ...	do ...	10-12-05	...	6 years	
Swamp Oak ...	268	1 log	6ft. long, 3ft. 9in. girth ...	do. ...	12-12-05	Serpentine, S.W.R.	6 months	
Do. ...	456	do.	8ft. 7in. long, 3ft. 9in. girth	do. ...	26-1-06	do. ...	5 months	
Native Pear ...	270	do.	5ft. long, 3ft. 4in. girth ...	do. ...	12-12-05	do. ...	6 months	
Do. ...	454	do.	6ft. 4in. long, 3ft. 8in. girth	do. ...	26-1-06	do. ...	5 months	

[Schedule

WESTERN AUSTRALIAN TIMBER TESTS, 1906.

RESULT OF CROSS-BENDING TESTS FOR BEAMS OF VARIOUS SIZES.

At 12 per cent. moisture.

ALL RESULTS ARE EXPRESSED IN LBS. PER SQUARE INCH.

Class of Timber.	For Beams up to 10 square inches Sectional Area.			For Beams up to 25 square inches Sectional Area.			For Beams over 25 square inches Sectional Area.		
	Ultimate extreme fibre stress.	Extreme fibre stress at apparent elastic limit.	Modulus of Elasticity.	Ultimate extreme fibre stress.	Extreme fibre stress at apparent elastic limit.	Modulus of Elasticity.	Ultimate extreme fibre stress.	Extreme fibre stress at apparent elastic limit.	Modulus of elasticity.
Jarrah	16,700	11,300	2,360,000	15,000	10,300	2,080,000	13,100	8,900	1,660,000
Karri	19,100	15,200	3,020,000	17,300	13,550	2,680,000	16,000	12,400	2,425,000
Tuart	20,300	17,550	2,800,000	17,900	15,900	2,560,000	16,250	14,400	2,380,000
Wandoo	18,250	15,150	2,450,000	16,100	13,650	2,190,000	14,000	11,700	1,910,000
Blackbutt	15,750	12,800	2,225,000	14,200	11,000	2,000,000	12,600	9,350	1,800,000
Red Gum	19,400	14,700	2,870,000	16,600	12,600	2,590,000	12,900	9,400	2,000,000
Yate	23,000	18,300	3,050,000	21,500	17,000	2,800,000	18,000	14,800	2,500,000
York Gum	15,800	12,500	2,000,000	14,000	10,800	1,700,000			
Salmon Gum	21,000	16,100	2,650,000	19,500	14,380	2,340,000			
Morrell	19,700	15,600	2,520,000	16,000	12,100	2,250,000			

[Schedule No. 4]

WESTERN AUSTRALIAN TIMBER TESTS, 1906.

APPROXIMATE VALUES OF THE "MOISTURE PERCENTAGE" AFTER VARIOUS PERIODS OF NATURAL SEASONING FOR TIMBER SAWN AND STACKED IN THE OPEN AND WELL VENTILATED.

Name of Timber.	"Moisture" per cent. of Dry Weight.											
	For all sizes "Green."	For sizes up to 30 square inches sectional area.				For sizes from 60 to 80 square inches sectional area.				For sizes over 100 square inches sectional area.		
		After 6 months.	1 year.	2 years.	3 years.	After 1 year.	2 years.	3 years.	5 years.	After 1 year.	3 years.	6 years.
Jarrah ...	50	34	26	17	13	33	25	19	14	39	28	21
Karri ...	54	38	29	21	14	37	28	21	15	43	31	22
Tuart ...	43	34	27	18	14	33	26	22	16	37	27	22
Wandoo...	28	24	21	17	15	23	20	17	15	25	20	17
Blackbutt	61	45	37	26	18	43	33	25	18	49	35	24
Red Gum	75	57	45	31	21	51	39	30	20	60	40	27
Yate ...	32	28	25	20	17	27	23	20	16	29	23	19

[Schedule No. 5.]

WESTERN AUSTRALIAN TIMBER TESTS, 1906.

RESULTS OF CHEMICAL EXAMINATION OF "SAPS."

Name of Timber.	Colour of Sap.	Nature of Sap.	Specific Gravity.	Percentage of Moisture and Volatile Matter.	Nature of Residue.	"Acidity" in terms of $H_2C_2O_4$.	Weight of Muntz Metal dissolved by 20 grammes of "Sap."	Weight of Wrought Iron dissolved by 20 grammes of "Sap."	Percentage of Tannin.	Volatile Acid expressed as Acetic Acid.
				per cent.		per cent.	grammes.	grammes.	per cent.	
Jarrah ...	Light reddish brown	Very thick fluid	1·001	99·5	Red brown film only	0·216	·0165	·1445	·07	Trace
Karri ...	Dark red ...	" " "	1·020	96·5	Brittle gum of bright red colour	1·458	·1080	·2240	·851	"
Tuart ...	Dark brown ...	"Thin" fluid ...	1·1085	77·7	Brown and friable	9·018	·0528	·1716	11·68	"
Wandoo ...	Red brown ...	Thick viscous fluid	1·1932	53·0	Hard dark gum, very dark brown in colour	7·614	·0160	·0770	17·00	"
Blackbutt ...	Very dark brown	Very fluid ...	1·0483	89·4	Brittle deposit, almost black	2·862	·0790	·1450	4·86	"
Red Gum ...	Red brown ...	" "	1·045	90·7	Gummy deposit, dark red colour	2·214	·0660	·1420	3·85	"
Yate ...	Very dark brown	" "	1·083	81·7	Dark brown deposit	7·587	·0500	·2330	12·03	0·5 per cent.

[Schedule No. 6.]

WESTERN AUSTRALIAN TIMBER TESTS.

HOLDING POWER OF DOG SPIKES IN SLEEPERS.

⅝in. Dog Spikes used in all cases. See Plate No. 26. Diameter of hole bored, ⅝in.

Class of Sleepers.	Length of Time in use.	Locality used.	Original Driving.					Redriven. (Spikes—all Class B.)		Remarks.
			Pull required in lbs.	No. of Tests.	Class of Spike. A.	B.	C.	Pull required in lbs.	No. of Tests.	
Jarrah ...	13 years	Mundijong, S.W.R. ...	1,641	40	32	8	...	2,991	75	Very wet district; sandy soil in cutting; rainfall between 30in. and 35in.; ironstone gravel ballast
Do. ...	11 years	Great Southern Railway...	...	...	...	...	...	2,696	8	Medium rainfall, between 14in. and 20in.; red loamy soil
Do. ...	New unused sleepers	... ...	...	...	...	...	...	5,676	24	
Do. ...	20 years	Newcastle Railway ...	1,809	19	1	4	14	...	...	Medium rainfall; mostly red loam and gravel country
Karri ...	19 years	1m. 26c., Great Southern Railway	3,309	21	10	...	11	3,690	20	Very wet district; rainfall, 35in. or over; sandy soil
Do. ...	New unused sleepers	... ...	...	...	...	...	...	6,731	16	
Wandoo ...	18 years	Newcastle Railway ...	3,403	30	29	1	...	5,170	30	Medium rainfall; mostly red loam and gravel country
Do. ...	8 years	Cue Railway	4,462	29	...	29	...	7,836	30	Very dry district; varying rainfall
Red Gum ...	4 years	Northam-Goomalling Railway	2,174	20	...	20	...	3,334	18	Medium rainfall; red loamy soil
Do. ...	4 years	Nannine Railway	6,787	29	...	29	...	5,922	30	Very dry district; varying rainfall
Blackbutt ...	4 years	Northam-Goomalling Railway	3,046	30	...	30	...	5,001	30	Medium rainfall; red loamy soil
Do. ...	4 years	Nannine Railway	2,259	29	15	14	...	4,602	30	Very dry district; varying rainfall

[Schedule No. 7.]

WESTERN AUSTRALIAN TIMBER TESTS. (L 1906.)

SUMMARY OF TESTS TO DETERMINE THE HOLDING POWER OF DOG SPIKES IN SLEEPERS.

Compared with the results of tests on "Sleepers" cut from other Hardwoods.

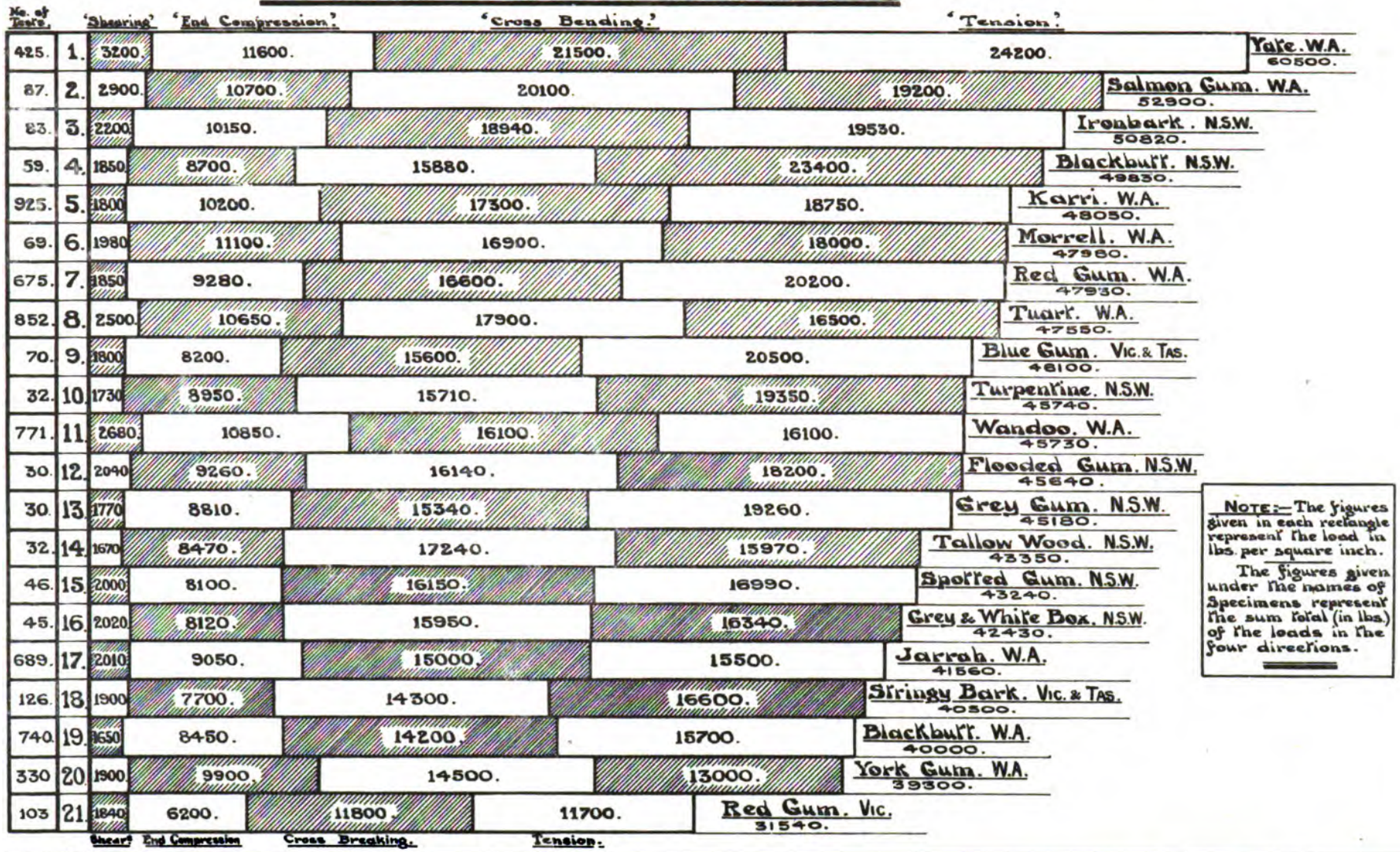
Name of Timber.	State.	Sleepers taken from Track with Spikes undisturbed.						Sleepers taken from Track re-driven Spikes in fresh holes.						New Sleepers and New Spikes.	
		Actual.			Average.			Actual.			Average.				
		No.	Age. Years.	Load.	No.	Age. Years.	Load.	No.	Age. Years.	Load.	No.	Age. Years.	Load.	No.	Load (Average).
Wandoo	Western Australia	30	18	3,403	...	...	...	30	18	5,170					
Do.	Western Australia	29	8	4,462	59	13	3,923	30	8	7,836	60	13	6,563		
Karri	Western Australia	21	19	3,309	21	19	3,309	20	19	3,690	20	19	3,690	16	6,731
Jarrah	Western Australia	40	13	1,641	59	16	1,695	75	13	2,991				24	5,676
Do.	Western Australia	19	20	1,809	...	...	...	8	11	2,696	83	12	2,962		
Red Gum	Western Australia	42	4	5,359	42	4	5,359	48	4	4,951	48	4	4,951		
Blackbutt	Western Australia	59	4	2,659	59	4	2,659	60	4	4,801	60	4	4,801		
Average of 5 Western Australian Timbers	... ...	...	...	...	240	11·2	3,389	...	...	...	271	10·4	4,581	40	6,203
Ironbark	Queensland and New South Wales ...	14	14·3	4,032	14	14·3	4,032	10	22·8	3,393	10	22	3,393	12	5,386
Spotted Gum	Queensland and New South Wales ...	4	4	2,325	4	4	2,325	8	8	4,472	8	8	4,472	4	4,466
Red Gum	Queensland	12	8	2,001	12	8	2,001	8	8	4,242	8	8	4,242		
Blue Gum	Queensland	8	11	2,933	8	11	2,933	8	8	4,307	8	8	4,307		
Gum Top Box	Queensland	8	8	4,066	8	8	4,066	8	8	2,860	8	8	2,860		
Red Stringy Bark	Queensland	8	6	3,082	8	6	3,082	4	13	2,975	4	13	2,975	8	4,039
White Stringy Bark	Queensland	4	7	1,335	4	7	1,335								
Tallow Wood	Queensland and New South Wales ...	4	9	2,775	4	9	2,775	4	13	2,491	4	13	2,491	8	3,223
Blood Wood	Queensland	4	24	2,375	4	24	2,375								
Messmate	Queensland	4	7	1,982	4	7	1,982								
Average of 10 Queensland Timbers	... ...	...	...	...	70	9·8	2,690	...	...	...	50	11·4	3,534	32	4,278

The results of tests of Queensland sleepers are quoted from "The Merchantable Timber of Queensland," published in 1905 by the Queensland Government.

By Authority: FRED. WM. SIMPSON, Government Printer, Perth.

Graphic Representation of the 'Strength' of Australasian Hardwoods.

W.A. Timber Tests.



NOTE:— The figures given in each rectangle represent the load in lbs. per square inch.

The figures given under the names of Specimens represent the sum total (in lbs.) of the loads in the four directions.

Plate No. I

PARTICULARS OF TIMBER RECEIVED FOR TESTING—*continued.*

Name of Timber.	Sample Nos.	Nature of Specimen.	Bulk Size.	Obtained from	Date received.	Locality grown.	Age when Tested.	Remarks.
Wandoo ...	292	1 log	15ft. long, 6ft. girth	Purchased through C.R.S. Branch	13-12-05	65m. 48c. on Newcastle Railway	Felled within 3 months	
Do.	293	do.	15ft. 4in. long, 5ft. 7in. girth	do. ...	13-12-05	62m. 74c. ...	1 year	
Do.	301 to 315	Hewn sleepers ...	15/7ft. x 8in. x 4in.	C.E.E.L. Branch	19-12-05	...	8 years	8 years in "road" on Cue railway
Do.	469 to 474	Sawn timber ...	6/6ft. x 3in. x 3in.	Hudson & Richie, Fremantle	11-4-06	Wooroloo, Eastern Railway	9 months	
Do.	505 to 506	Dressed specimens	2/7ft. 6in. x 10in. x 4in.	do. ...	1-5-06	do. ...	9 months	
Do.	507 to 510	do. ...	4/6ft. x 6ft. x 4in.	do. ...	1-5-06	do. ...	9 months	
Blackbutt ...	90 to 101	Sawn Timber ...	12/11ft. x 4in. x 3in. ...	Railway Contract Supply, Way and Works Branch	10-11-1905	S.W. District ...	8 months	
Do.	211	do. ...	7ft. x 12in. x 4in. ...	Millar's Karri and Jarrah Co.	28-11-1905	Yarloop S.W. Railway	4 years	Headstock 4 years in log truck
Do.	212	do. ...	7ft. x 9in. x 3in. ...	do. do. ...	28-11-1905	do. ...	2½ years	
Do.	213	do. ...	7ft. x 12in. x 5in. ...	do. do. ...	28-11-1905	do. ...	4½ years	
Do.	214	do. ...	8ft. x 10in. x 4½in. ...	do. do. ...	28-11-1905	do. ...	20 months	
Do.	215	do. ...	12ft. x 9in. x 5in. ...	do. do. ...	28-11-1905	do. ...	9 months	
Do.	216	do. ...	11ft. x 9in. x 5in. ...	do. do. ...	28-11-1905	do. ...	4¾ years	Used in log truck sole bar for 4¾ years
Do.	217	do. ..	7ft. x 10in. x 3½in. ...	do. do. ...	28-11-1905	do. ...	20 months	
Do.	235	1 log	15ft. 4in. long, 7ft. 10in. girth	Purchased through C.R.S. Branch	5-12-1905	Kirrup, Bridgetown Railway	Felled within 3 months	
Do.	236	do.	15ft. 2in. long, 8ft. 6in. girth	do. do. ...	5-12-1905	do. ...	8 years	
Do.	250 to 261	Sawn sleepers ...	12/7ft. x 8½in. x 4in.	C.E.E.L. Branch	7-12-05	S.W. District ...	4 years	4 years in Northam-Goomalling Railway
Do.	262	Sawn timber ...	6ft. x 10in. x 4½in.	Millar's Karri and Jarrah Co.	7-12-05	Yarloop S.W. Railway	5 years	
Do.	263	do. ...	6ft. 6in. x 11in. x 4½in.	do. ...	7-12-05	do. ...	5 years	
Do.	264 and 265	do. ...	2/6ft. x 9in. x 5in.	do. ...	7-12-05	do. ...	5 years	
Do.	266	do. ...	6ft. x 8½in. x 5in.	do. ...	7-12-05	do. ...	5 years	
Do.	267	do. ...	6ft. x 8¾in. x 5in.	do. ...	7-12-05	do. ...	5 years	
Do.	271 to 273	Sawn sleepers ...	3/7ft. x 8½in. x 4in.	C.E.E.L. Branch	7-12-05	S.W. District ...	4 years	4 years in "road" Northam-Goomalling Railway
Do.	331 to 345	do. ...	15/7ft. x 8in. x 4in.	do. ...	19-12-05	do. ...	4 years	4 years in "road" Nannine Railway
Do.	406 to 422	Sawn beams ...	17/13ft. x 12¼in. x 4¼in.	Millar's Karri and Jarrah Co.	6-2-06	Yarloop S.W. Railway	Felled within 3 months	
Do.	423 to 426	do. ...	4/13ft. x 12¼in. x 4¼in.	do. ...	6-2-06	do. ...	1 year	
Do.	427 to 441	Sawn timber ...	15/6ft. x 4¼in. x 4¼in.	do. ...	6-2-06	do. ...	1 year	
Do.	442 to 452	do. ...	11/6ft. x 4¼in. x 4¼in.	do. ...	6-2-06	do. ...	Felled within 3 months	
Red Gum ...	233	1 log	15ft. 4in. long, 7ft. 8in. girth	Purchased through C.R.S. Branch	5-12-05	Kirrup, Bridgetown Railway	8 years	
Do. ...	234	do.	15ft. 6in. long, 7ft. 1in. girth	do.	5-12-05	do. ...	Felled within 3 months	
Do. ...	240 to 249	Sawn sleepers ...	10/7ft. x 8½in. x 4in. ...	C.E.E.L. Branch	7-12-05	S.W. Railway ...	4 years	4 years in "road," Northam-Goomalling Railway
Do. ...	316 to 330	do.	15/7ft. x 8½in. x 4in. ...	do.	19-12-05	do. ...	4 years	4 years in "road," Nannine Railway
Do. ...	367 to 380	Sawn beams ...	14/13ft. x 12¼in. x 4¼in. ...	Millar's Karri and Jarrah Co.	6-2-06	Yarloop, S.W. Railway	Felled within 3 months	
Do. ...	381 to 405	do.	25/6ft. x 4¼in. x 4¼in. ...	do.	6-2-06	do. ...	do.	

PARTICULARS OF TIMBER RECEIVED FOR TESTING—*continued.*

Name of Timber.	Sample Nos.	Nature of Specimen.	Bulk Size.	Obtained from	Date Received.	Locality grown.	Age when tested.	Remarks.
Yate	239	1 log	16ft. 2in. long, 4ft. 9in. girth	Purchased through C.R.S. Branch	5-12-05	Capel, Bridgetown Railway	Felled within 3 months	
Do. ...	460	do.	15ft. 6in. long, 6ft. 1in. girth	do.	9-3-06	Mt. Barker, G.S. Railway	do.	
Do. ...	461	do.	8ft. 3in. long., 5ft. 10in. girth	do.	9-3-06	do. ...	3 years	3 years felled
York Gum ...	139	do.	5ft. 11in. long, 4ft. girth ...	C.E.E.L. Branch	20-11-05	Northam District	Felled within 3 months	
Do. ...	140	do.	6ft. long, 3ft. 2in. girth ...	do. ...	20-11-05	do. ...	3 years	
Do. ...	141	do.	5ft. 2¼in. long, 4ft. 7in. girth	do. ...	20-11-05	Newcastle District	4 years	63¼-miles on Newcastle Line (cut).
Do. ...	142	do.	6ft. long, 3ft. 3in. girth ...	do. ...	20-11-05	do. ...	Felled within 3 months	63¾-miles on Newcastle Line (cut)
Do. ...	223	do.	5ft. 6in. long, 3ft. 2in. girth	Millar's Karri and Jarrah Co.	28-11-05	Cut near Northam	do.	
Do. ...	224	do.	7ft. long, 2ft. 10in. girth	do. ...	28-11-05	do. ...	Over 3 years.	
Do. ...	225	do.	3ft. 4in. long, 3ft. 2in. girth	do. ...	28-11-05	do. ...	Felled within 3 months	
Do. ...	226	do.	8ft. long, 2ft. 3in. girth ...	do. ...	28-11-05	do. ...	do.	
Do. ...	227	do.	5ft. 6in. long, 2ft. 3in. girth	do. ...	28-11-05	do. ...	do.	
Do. ...	289	do.	10ft. 5in. long, 6ft. 4in. girth	Chief Engineer Existing Lines Branch	13-12-05	Newcastle District	do.	Cut 63 miles 6 chains on Newcastle Line
Do. ...	294	do.	11ft. 5in. long, 5ft. 7in. girth	do. ...	13-12-05	do. ...	do.	Cut 63 miles 60 chains on Newcastle Line
Do. ...	466	do.	11ft. 10in. long, 3ft. girth	Purchased through C.R.S. Branch	3-4-06	Newcastle District	Felled within 3 months	
Do. ...	467	do.	16ft. long, 3ft. 9in. girth...	do. do. ...	3-4-06	do. ...	do.	
Salmon Gum ...	297	do.	12ft. 5in. long, 3ft. 3in. girth	Midland Railway Company	18-12-05	Near Moora, Midland Railway	do.	
Do. ...	298	do.	12ft. 11in. long, 3ft. 1in. girth	do. ...	18-12-05	do. ...	Over 2 years	
Morrell ...	299	do.	12ft. 5in. long, 2ft. 7in. girth	do. ...	18-12-05	do. ...	Felled within 3 months	
Do. ...	300	do.	12ft. 5in. long, 2ft. 9in. girth	do. ...	18-12-05	do. ...	Over 2 years	
Do. ...	465	do.	11ft. 7in. long, 4ft. 9in. girth	Purchased through C.R.S. Branch	3-4-06	14 miles N.E. of Newcastle	Felled within 3 months	
Sheoak ...	269	do.	6ft. long, 4ft. 4in. girth ...	do. ...	12-12-05	Serpentine, S.W.R.	6 months	
Do. ...	455	do.	6ft. 7in. long, 4ft. 11in. girth	do. ...	26-1-06	do. ...	5 months	
Banksia ...	232	Hewn baulks ...	2/5ft. x 20in. x 10in. ...	do. ...	30-11-05	Mullalyup-Bridgetown Railway	7 months	
Do. ...	296	do.	1/10in. x 22½in. x 10in. ...	do. ...	30-11-05	do. ...	do.	
Jam Wood ...	219	1 log	6ft. long, 2ft. 4in. girth ...	do. ...	29-11-05	Kelmscott, S.W.R.	do.	
Do. ...	453	1 slab, hewn ...	6ft. long x 5½in. x 3in. ...	do ...	10-12-05	...	6 years	
Swamp Oak ...	268	1 log	6ft. long, 3ft. 9in. girth ...	do. ...	12-12-05	Serpentine, S.W.R.	6 months	
Do. ...	456	do.	8ft. 7in. long, 3ft. 9in. girth	do. ...	26-1-06	do. ...	5 months	
Native Pear ...	270	do.	5ft. long, 3ft. 4in. girth ...	do. ...	12-12-05	do. ...	6 months	
Do. ...	454	do.	6ft. 4in. long, 3ft. 8in. girth	do. ...	26-1-06	do. ...	5 months	

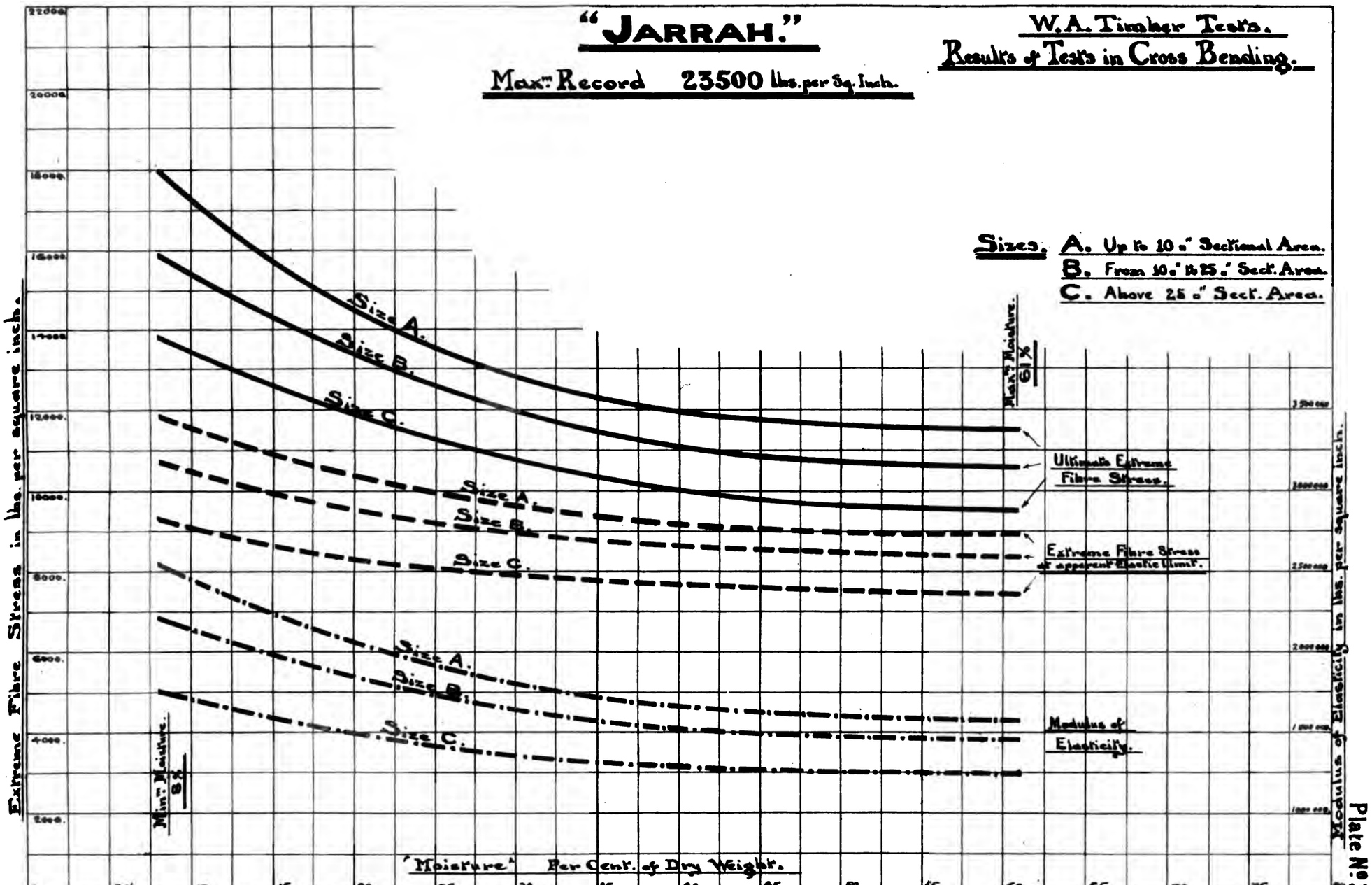

"JARRAH."
Max.m Record 23500 lbs. per Sq. Inch.
W.A. Timber Tests.
Results of Tests in Cross Bending.
Sizes. A. Up to 10 □" Sectional Area.
B. From 10 □" to 25 □" Sect. Area.
C. Above 25 □" Sect. Area.
Size A.
Size B.
Size C.
Size A.
Size B.
Size C.
Size A.
Size B.
Size C.
Max.m Moisture. 61%
Min.m Moisture. 8%
Ultimate Extreme Fibre Stress.
Extreme Fibre Stress at apparent Elastic Limit.
Modulus of Elasticity.
Extreme Fibre Stress in lbs. per square inch.
Modulus of Elasticity in lbs. per square inch.
"Moisture" Per Cent. of Dry Weight.
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
5%
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80

Plate No 3

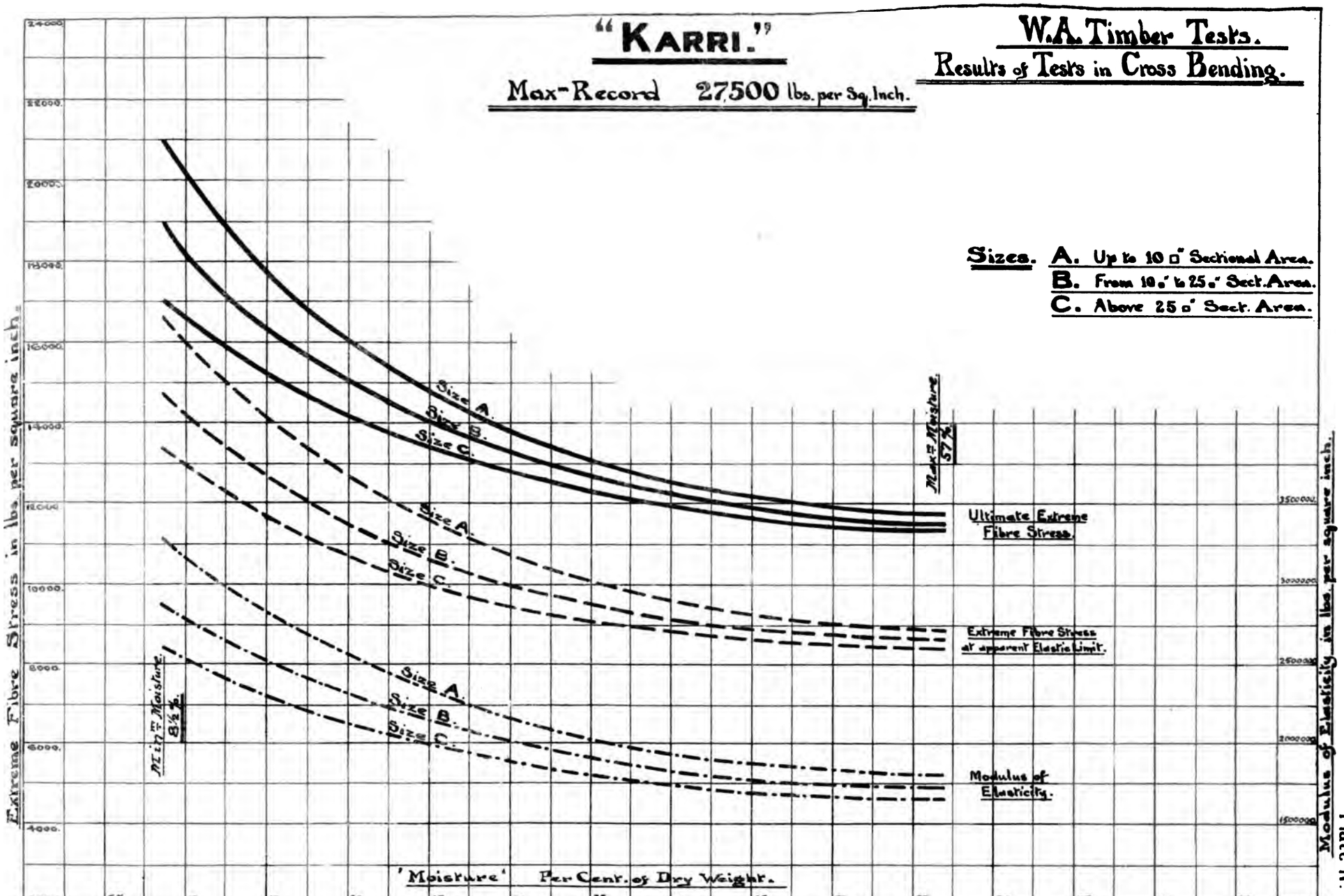

"KARRI."
Max^m Record 27,500 lbs. per Sq. Inch.
W.A. Timber Tests.
Results of Tests in Cross Bending.
Sizes. A. Up to 10 □" Sectional Area.
B. From 10 □" to 25 □" Sect. Area.
C. Above 25 □" Sect. Area.
Size A.
Size B.
Size C.
Max^m Moisture. 57%
Ultimate Extreme Fibre Stress.
Extreme Fibre Stress at apparent Elastic Limit.
Modulus of Elasticity.
Min^m Moisture. 8½%
Extreme Fibre Stress in lbs. per square inch.
Modulus of Elasticity in lbs. per square inch.
'Moisture' Per Cent. of Dry Weight.
24000.
22000.
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0.
5%
10.
15.
20.
25.
30.
35.
40.
45.
50.
55.
60.
65.
70.
75.
3500000.
3000000.
2500000.
2000000.
1500000.
1000000.
0.

Plate No. 4

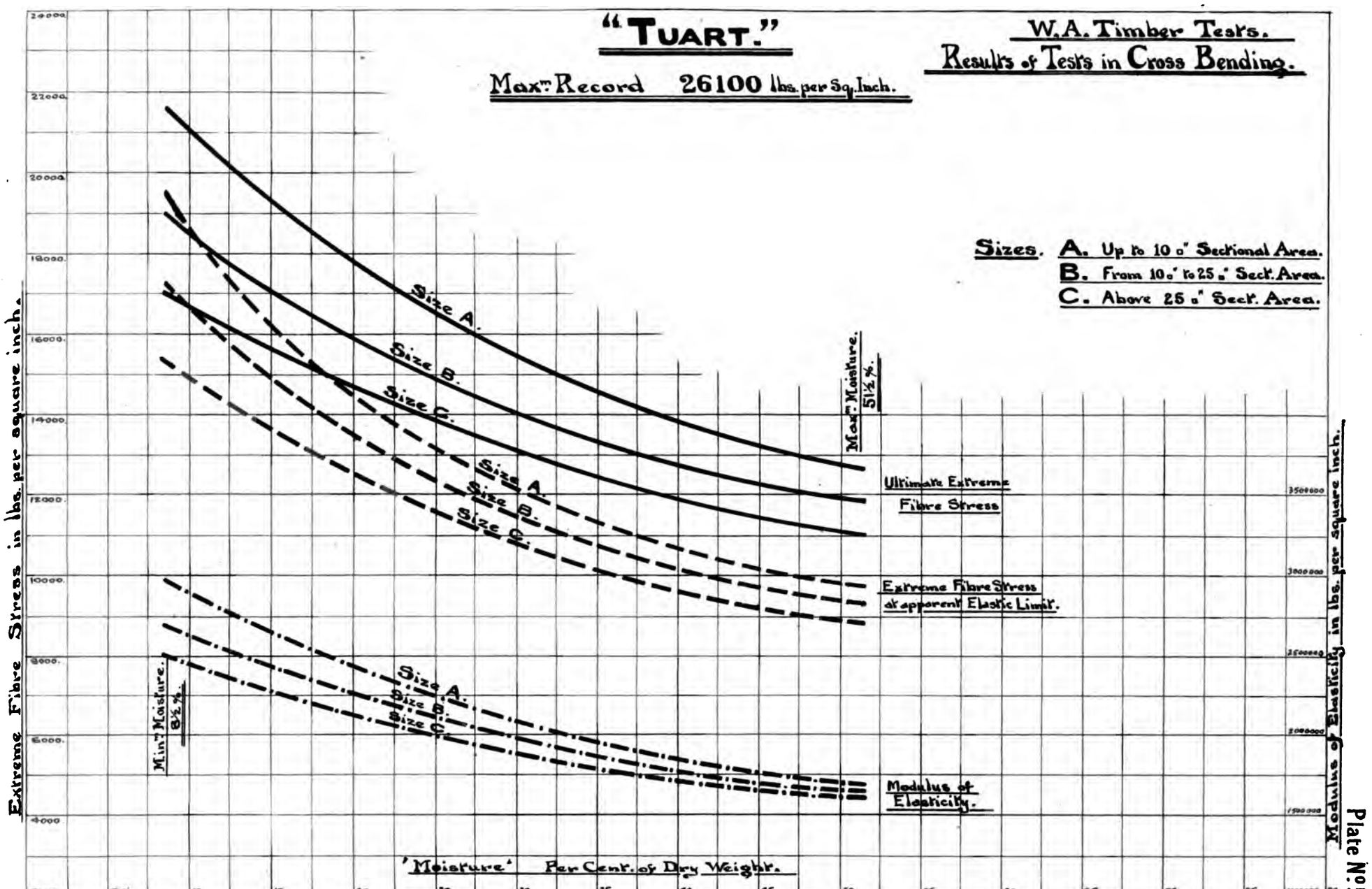

"TUART."
Max.m Record 26100 lbs. per Sq. Inch.
W.A. Timber Tests.
Results of Tests in Cross Bending.
Sizes. A. Up to 10 □" Sectional Area.
B. From 10 □" to 25 □" Sect. Area.
C. Above 25 □" Sect. Area.
Extreme Fibre Stress in lbs. per square inch.
Modulus of Elasticity in lbs. per square inch.
Size A.
Size B.
Size C.
Max.m Moisture. 51½%.
Ultimate Extreme Fibre Stress
Extreme Fibre Stress at apparent Elastic Limit.
Modulus of Elasticity.
Min.m Moisture. 8½%.
'Moisture' Per Cent. of Dry Weight.

Plate No. 5

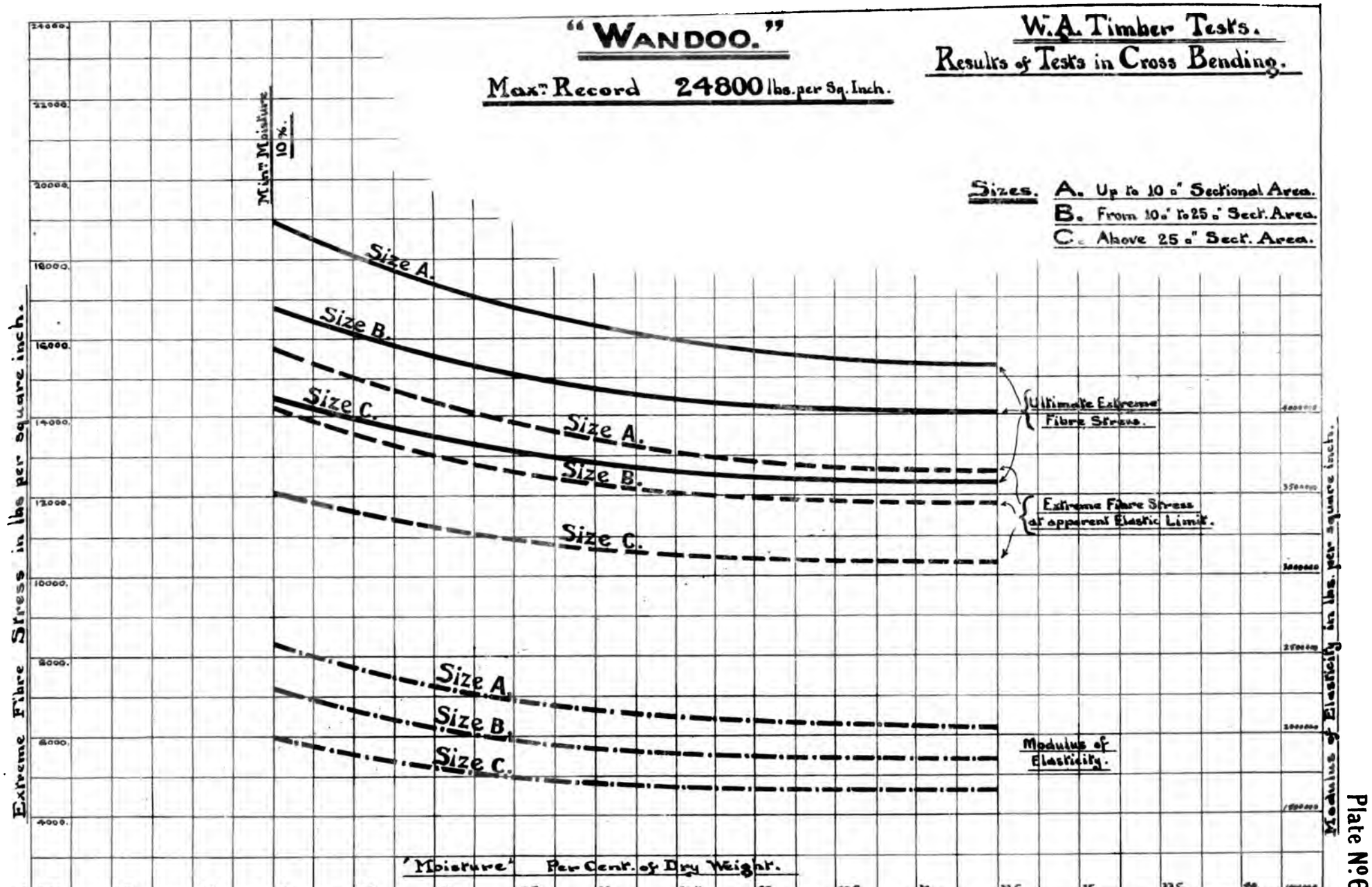

"WANDOO."
Max.m Record 24800 lbs. per Sq. Inch.
W.A. Timber Tests.
Results of Tests in Cross Bending.
Min.m Moisture 10%.
Sizes. A. Up to 10 □" Sectional Area.
B. From 10 □" to 25 □" Sect. Area.
C. Above 25 □" Sect. Area.
Size A.
Size B.
Size C.
Size A.
Size B.
Size C.
Size A.
Size B.
Size C.
Ultimate Extreme Fibre Stress.
Extreme Fibre Stress at apparent Elastic Limit.
Modulus of Elasticity.
Extreme Fibre Stress in lbs per square inch.
Modulus of Elasticity in lbs. per square inch.
'Moisture' Per Cent. of Dry Weight.
24000.
22000.
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000
0
5%
7.5
10.
12.5.
15.
17.5.
20.
22.5.
25.
27.5
30.
32.5.
35.
37.5.
40.

Plate No. 6

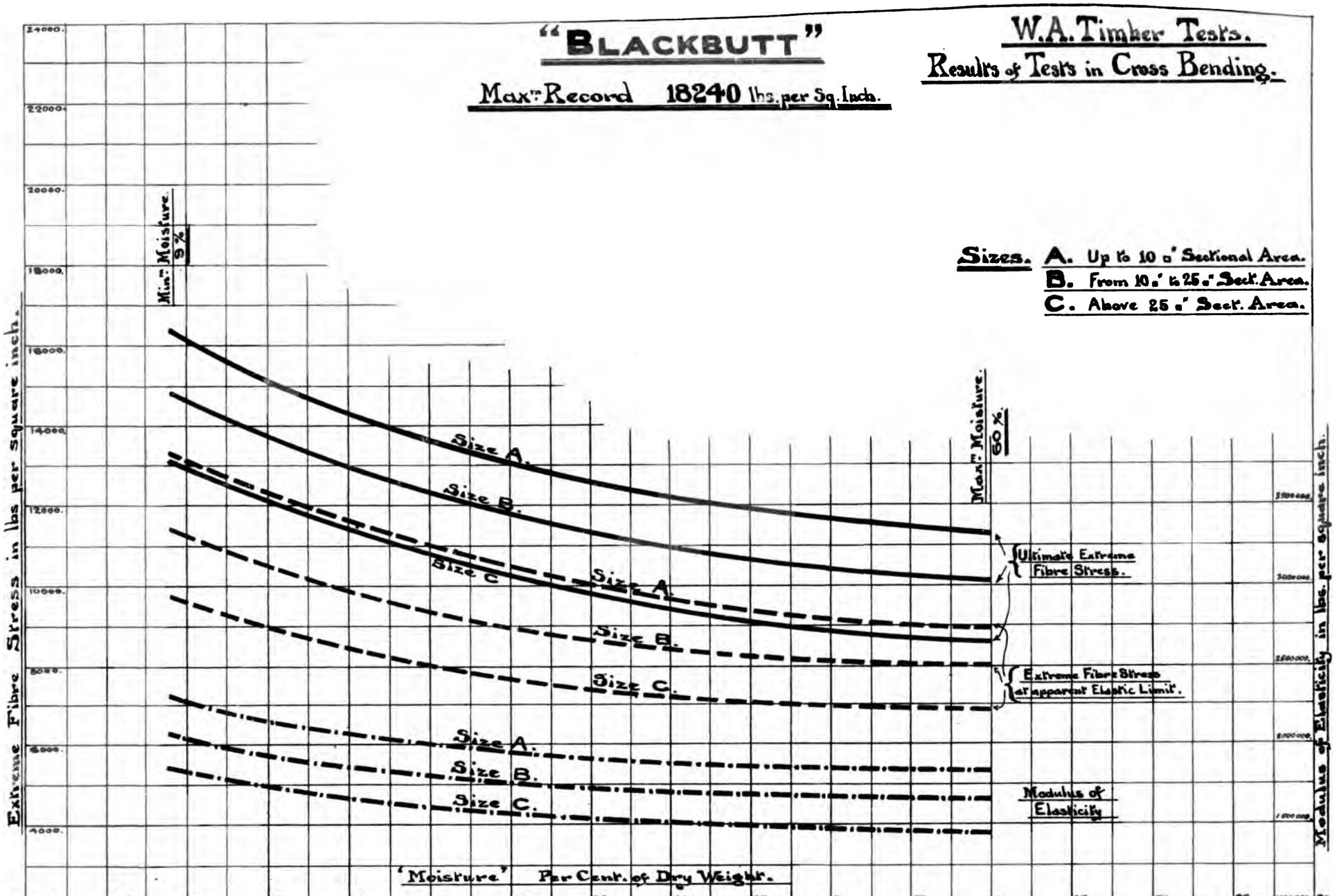

"BLACKBUTT"
Max.m Record 18240 lbs. per Sq. Inch.
W.A. Timber Tests.
Results of Tests in Cross Bending.
Sizes. A. Up to 10 □" Sectional Area.
B. From 10 □" to 25 □" Sect. Area.
C. Above 25 □" Sect. Area.
Min.m Moisture. 5%
Max.m Moisture. 60%
Size A.
Size B.
Size C
Size A.
Size B.
Size C.
Size A.
Size B.
Size C.
Ultimate Extreme Fibre Stress.
Extreme Fibre Stress at apparent Elastic Limit.
Modulus of Elasticity
Extreme Fibre Stress in lbs per square inch.
Modulus of Elasticity in lbs. per square inch.
'Moisture' Per Cent. of Dry Weight.
24000.
22000.
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000.
5%
10.
15.
20.
25.
30.
35.
40.
45.
50.
55.
60.
65.
70.
75.
80.

Plate No. 7

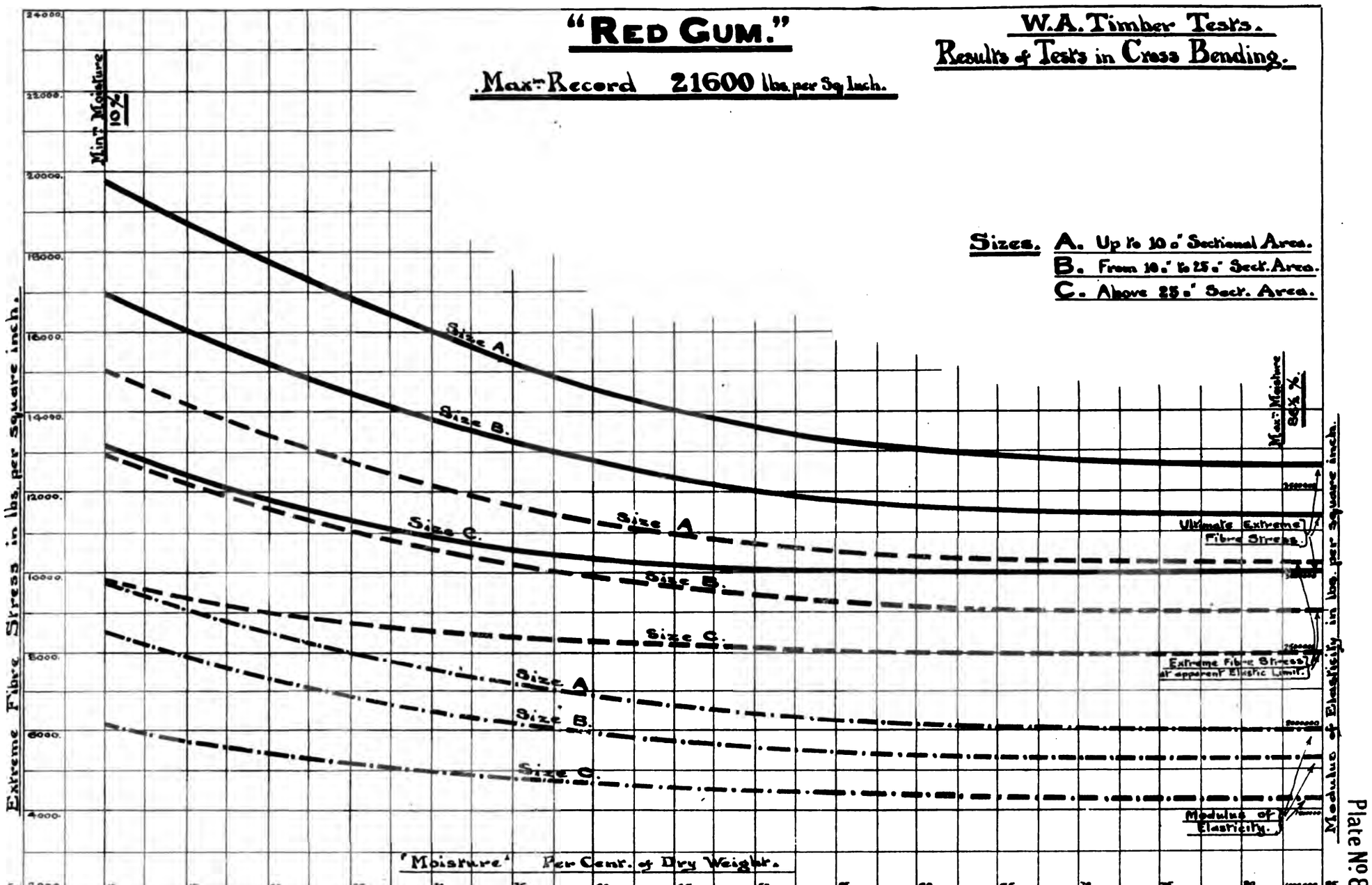
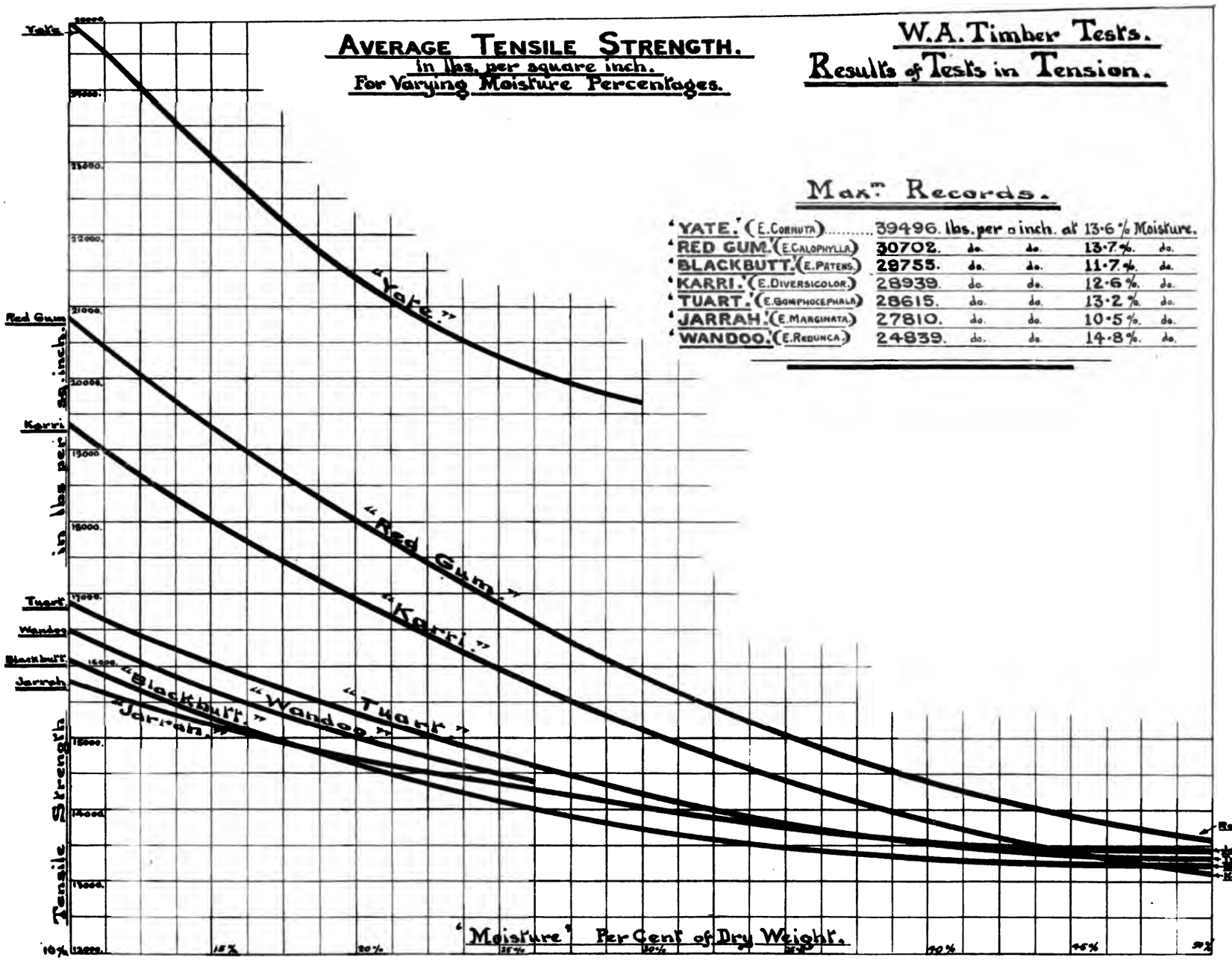

"RED GUM."
Max.m Record 21600 lbs. per Sq. Inch.
W.A. Timber Tests.
Results of Tests in Cross Bending.
Sizes. A. Up to 10 □" Sectional Area.
B. From 10 □" to 25 □" Sect. Area.
C. Above 25 □" Sect. Area.
Min.m Moisture 10%
Max.m Moisture 86½%
Size A.
Size B.
Size C.
Size A
Size B.
Size C.
Size A
Size B.
Size C.
Ultimate Extreme Fibre Stress.
Extreme Fibre Stress at apparent Elastic Limit.
Modulus of Elasticity.
Extreme Fibre Stress in lbs. per square inch.
Modulus of Elasticity in lbs. per square inch.
24000.
22000.
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000.
5 %
10.
15.
20.
25.
30.
35.
40.
45.
50.
55.
60.
65.
70
75.
80.
85.
'Moisture' Per Cent. of Dry Weight.

Plate No. 8

W.A. Timber Tests.

Results of Tests in Tension.



Max^m Records.

'YATE.' (E. CORNUTA)	39496.	lbs. per □ inch.	at	13·6 %	Moisture.
'RED GUM.' (E. CALOPHYLLA)	30702.	do.	do.	13·7 %.	do.
'BLACKBUTT.' (E. PATENS.)	29755.	do.	do.	11·7 %.	do.
'KARRI.' (E. DIVERSICOLOR.)	28939.	do.	do.	12·6 %.	do.
'TUART.' (E. GOMPHOCEPHALA)	28615.	do.	do.	13·2 %.	do.
'JARRAH.' (E. MARGINATA)	27810.	do.	do.	10·5 %.	do.
'WANDOO.' (E. REDUNCA.)	24839.	do.	do.	14·8 %.	do.

Plate No. 9

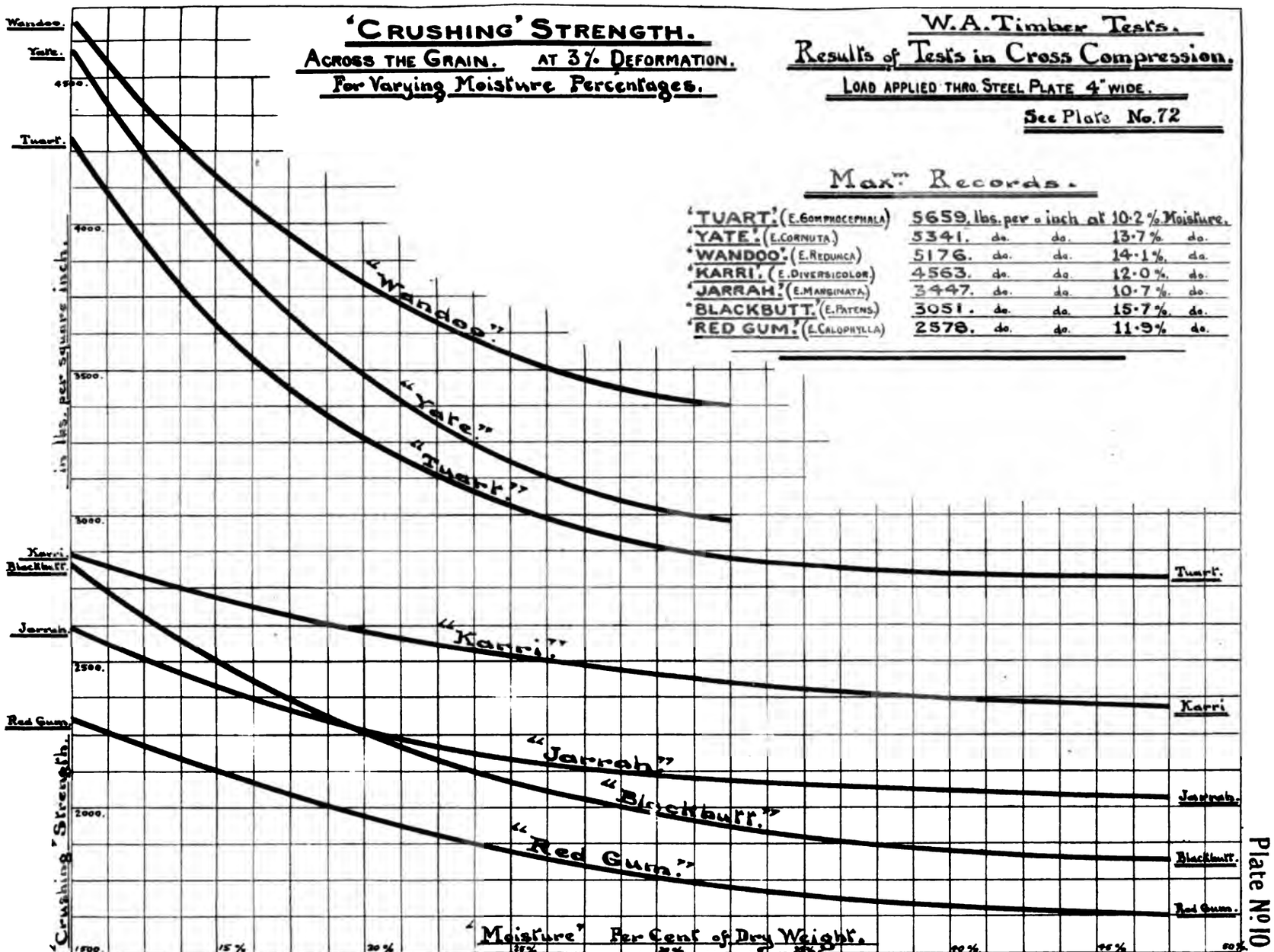

'CRUSHING' STRENGTH.
ACROSS THE GRAIN. AT 3% DEFORMATION.
For Varying Moisture Percentages.
W.A. Timber Tests.
Results of Tests in Cross Compression.
LOAD APPLIED THRO. STEEL PLATE 4" WIDE.
See Plate No. 72
Max^m Records.
'TUART.' (E. GOMPHOCEPHALA) 5659. lbs. per □ inch at 10·2 % Moisture.
'YATE.' (E. CORNUTA) 5341. do. do. 13·7 % do.
'WANDOO.' (E. REDUNCA) 5176. do. do. 14·1 %. do.
'KARRI.' (E. DIVERSICOLOR) 4563. do. do. 12·0 %. do.
'JARRAH.' (E. MARGINATA) 3447. do. do. 10·7 %. do.
'BLACKBUTT.' (E. PATENS) 3051. do. do. 15·7 %. do.
'RED GUM.' (E. CALOPHYLLA) 2578. do. do. 11·9 % do.
Wandoo.
Yate.
Tuart.
Karri.
Blackbutt.
Jarrah.
Red Gum.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
in lbs. per square inch.
'Crushing' Strength.
"Wandoo."
"Yate."
"Tuart."
"Karri."
"Jarrah."
"Blackburr."
"Red Gum."
Tuart.
Karri
Jarrah.
Blackbutt.
Red Gum.
'Moisture' Per Cent of Dry Weight.
10 %
15 %
20 %
25 %
30 %
35 %
40 %
45 %
50 %

Plate No. 10

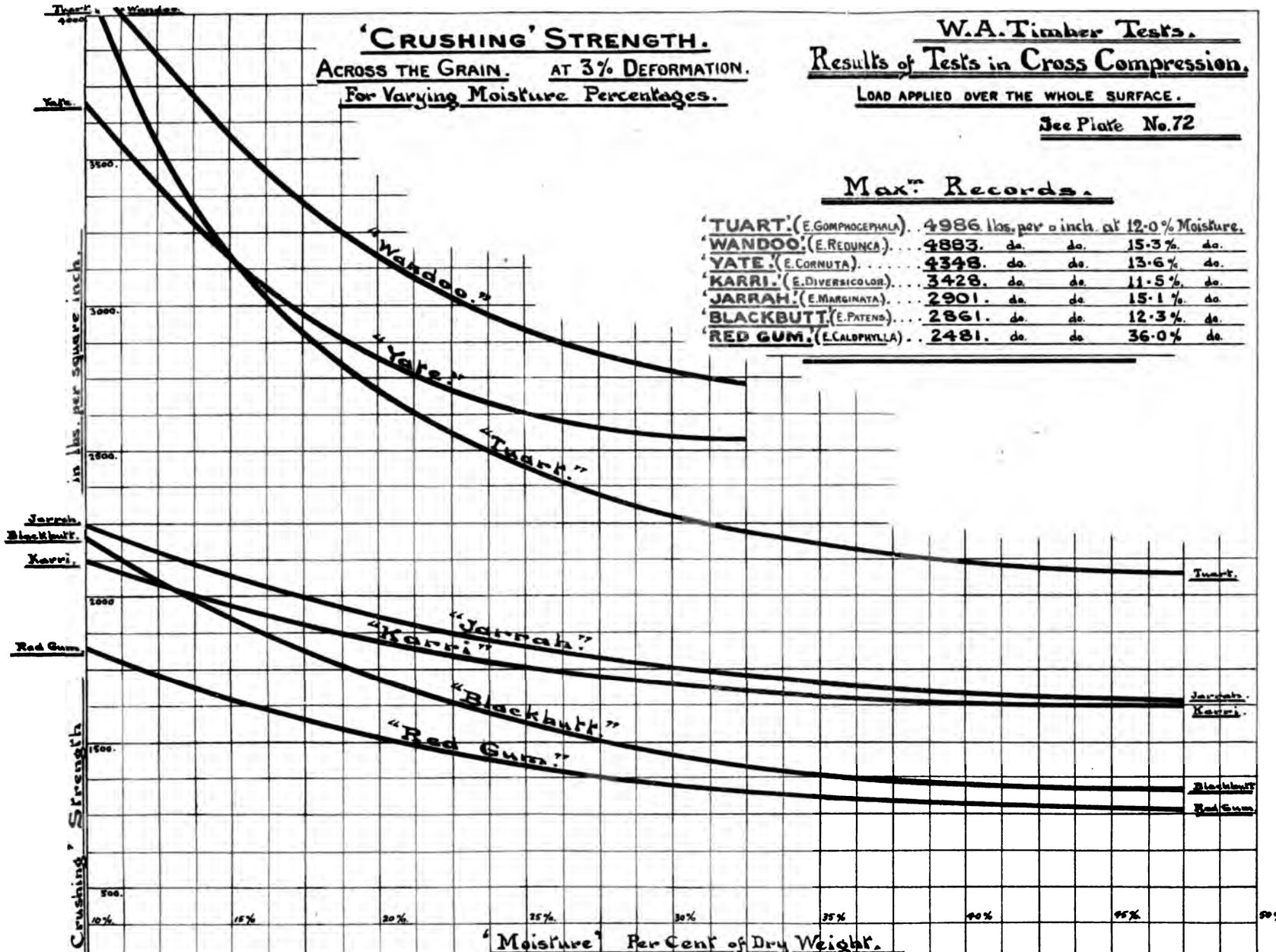

'CRUSHING' STRENGTH.
ACROSS THE GRAIN. AT 3% DEFORMATION.
For Varying Moisture Percentages.
W.A. Timber Tests.
Results of Tests in Cross Compression.
LOAD APPLIED OVER THE WHOLE SURFACE.
See Plate No.72
Max^m Records.
'TUART.' (E. GOMPHOCEPHALA) . . 4986. lbs. per □ inch. at 12·0% Moisture.
'WANDOO.' (E. REDUNCA) . . . . 4883. do. do. 15·3%. do.
'YATE.' (E. CORNUTA) . . . . . 4348. do. do. 13·6%. do.
'KARRI.' (E. DIVERSICOLOR) . . . . 3428. do. do. 11·5%. do.
'JARRAH.' (E. MARGINATA) . . . . 2901. do. do. 15·1%. do.
'BLACKBUTT.' (E. PATENS) . . . . 2861. do. do. 12·3%. do.
'RED GUM.' (E. CALOPHYLLA) . . 2481. do. do. 36·0% do.
Tuart.
Wandoo.
Yate.
Jarrah.
Blackbutt.
Karri.
Red Gum.
"Wandoo."
"Yate."
"Tuart."
"Jarrah."
"Karri."
"Blackbutt."
"Red Gum."
'Crushing' Strength in lbs. per square inch.
4000.
3500.
3000.
2500.
2000
1500.
500.
10%.
15%
20%.
25%.
30%
35%
40%
45%.
50%
'Moisture' Per Cent of Dry Weight.

Plate No. 11

Plate No. 12

Average Crushing Strength.

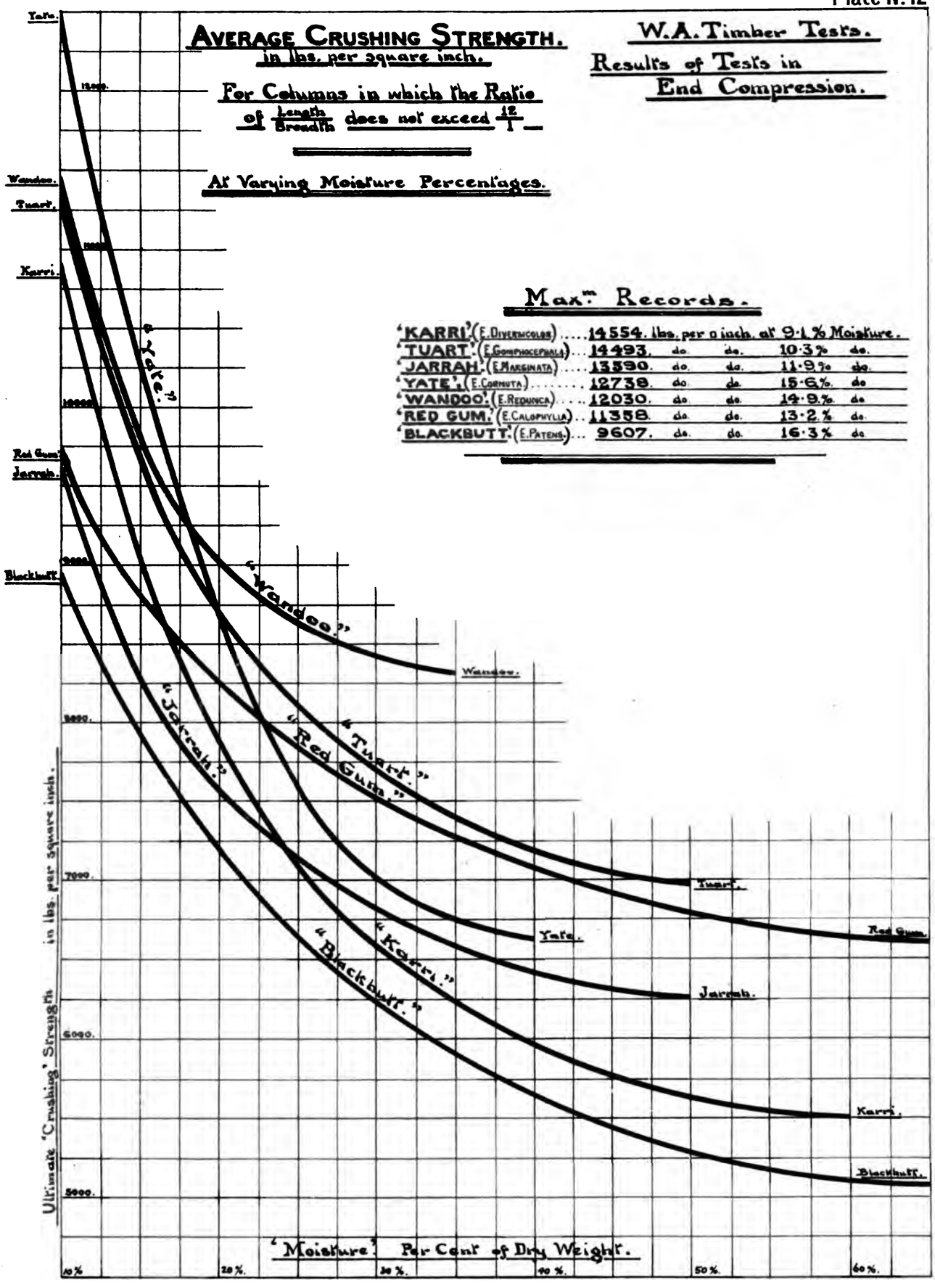
in lbs. per square inch.

For Columns in which the Ratio of $\frac{\text{Length}}{\text{Breadth}}$ does not exceed $\frac{12}{1}$

At Varying Moisture Percentages.

W.A. Timber Tests.

Results of Tests in End Compression.

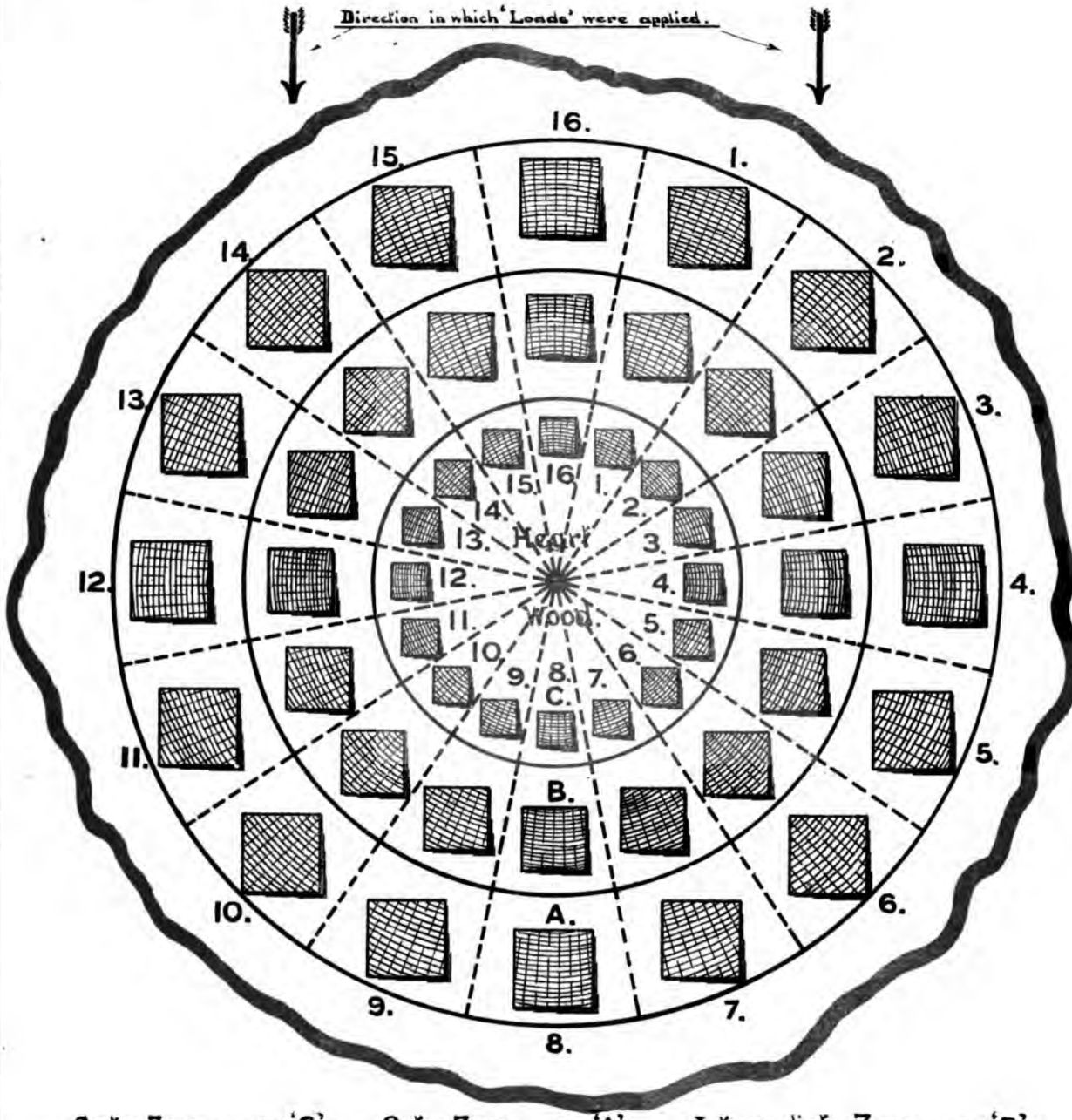


Max.m Records.

'KARRI' (E. Diversicolor)	14554.	lbs. per □ inch.	at	9·1 %	Moisture.
'TUART' (E. Gomphocephala)	14493.	do.	do.	10·3 %	do.
'JARRAH' (E. Marginata)	13590.	do.	do.	11·9 %	do.
'YATE' (E. Cornuta)	12738.	do.	do.	15·6 %	do.
'WANDOO' (E. Redunca)	12030.	do.	do.	14·9 %	do.
'RED GUM' (E. Calophylla)	11358.	do.	do.	13·2 %	do.
'BLACKBUTT' (E. Patens)	9607.	do.	do.	16·3 %	do.

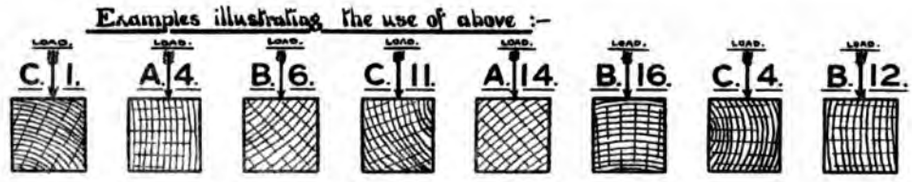
W.A. Timber Tests.

DIAGRAM ILLUSTRATING METHOD OF RECORDING THE DIRECTION IN WHICH 'LOADS' WERE APPLIED RELATIVE TO THE POSITION OF THE 'ANNUAL RINGS' AS SHEWN UPON THE END SECTION OF THE SPECIMENS.



Centre Zone, marked 'C'. Outer Zone, marked 'A'. Intermediate Zone, marked 'B'.

Examples illustrating the use of above :-



WATER OVEN.

FOR DRYING MOISTURE SECTIONS.

W.A. Timber Tests.

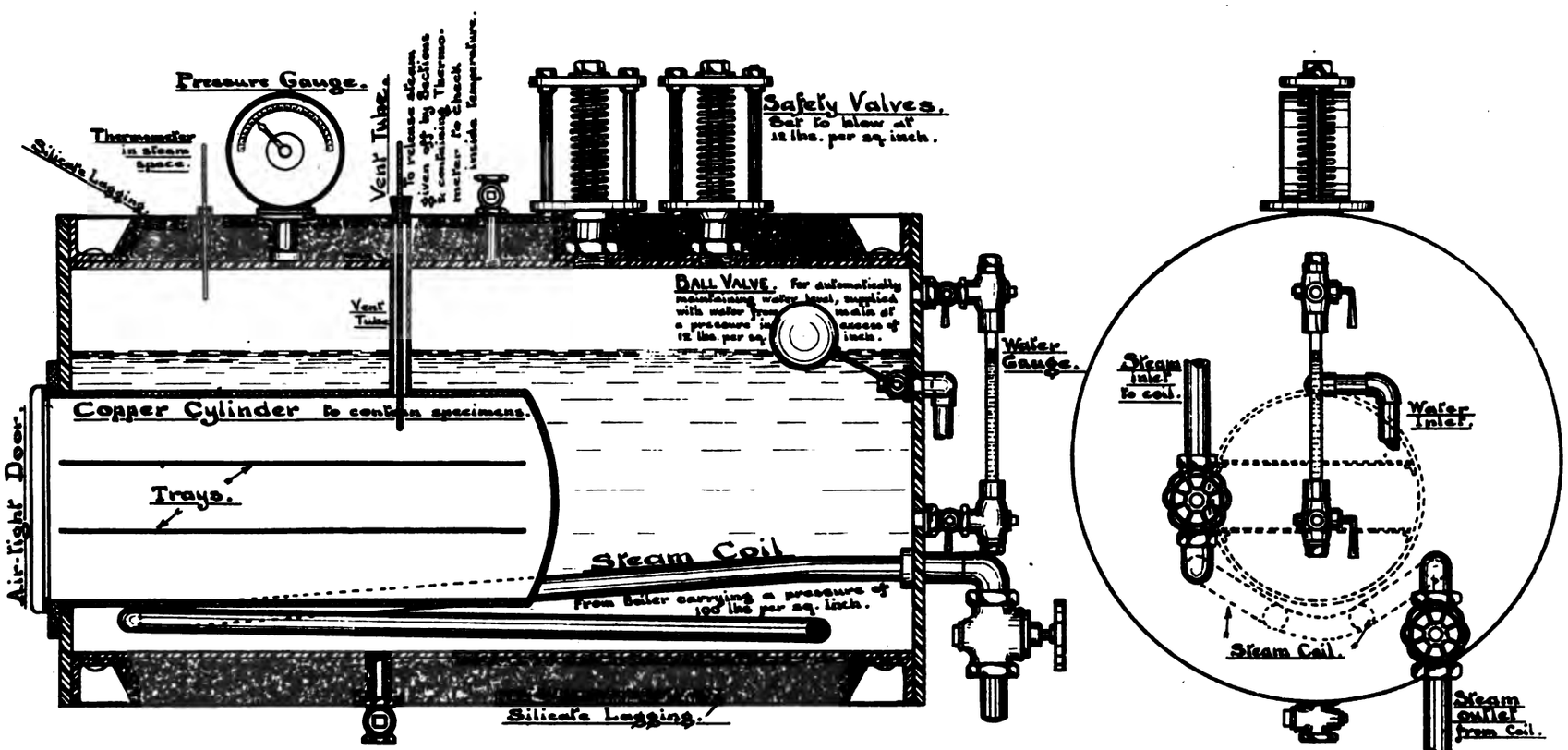
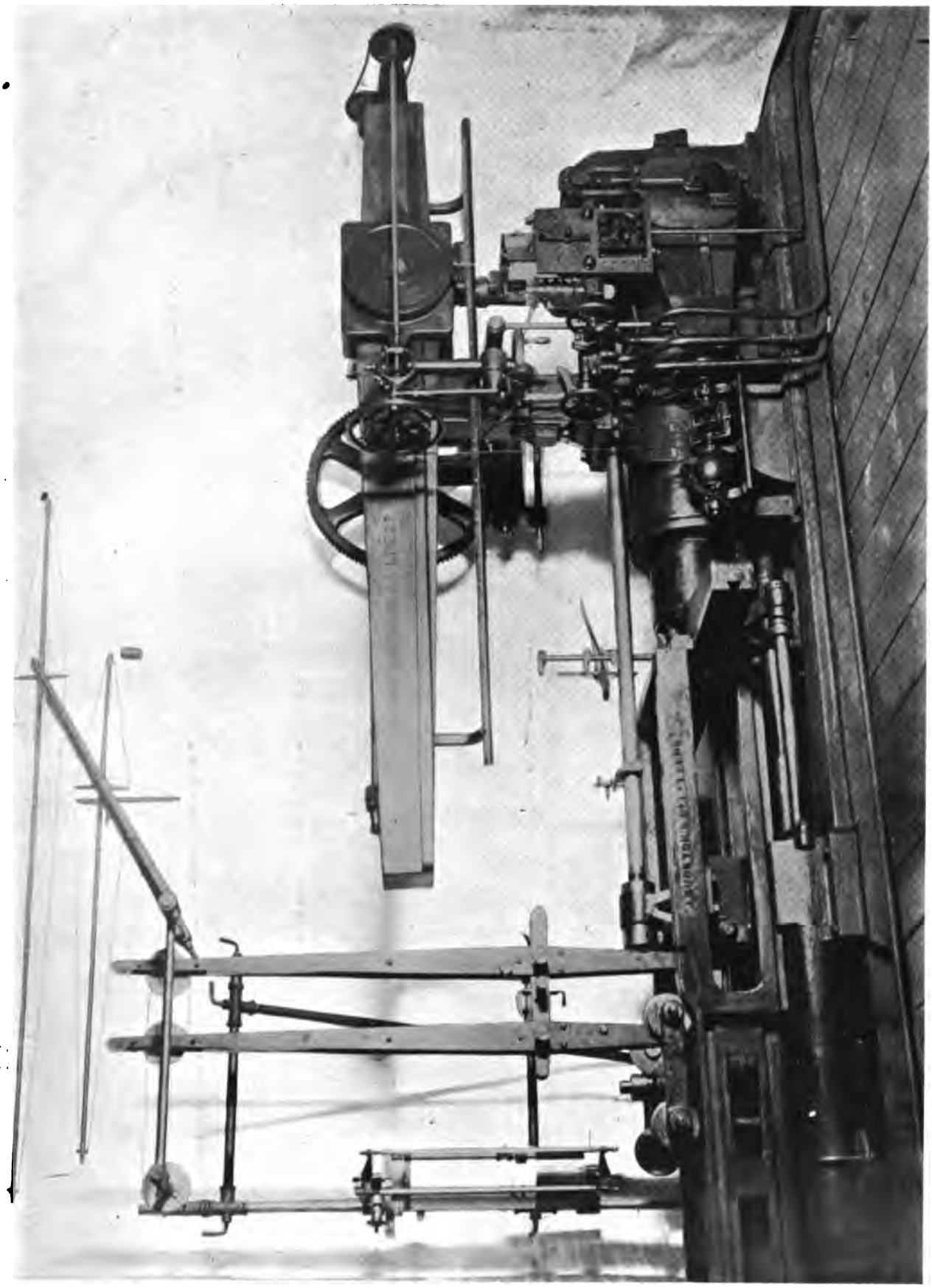


Plate No. 14

W.A. TIMBER TESTS, 1906.

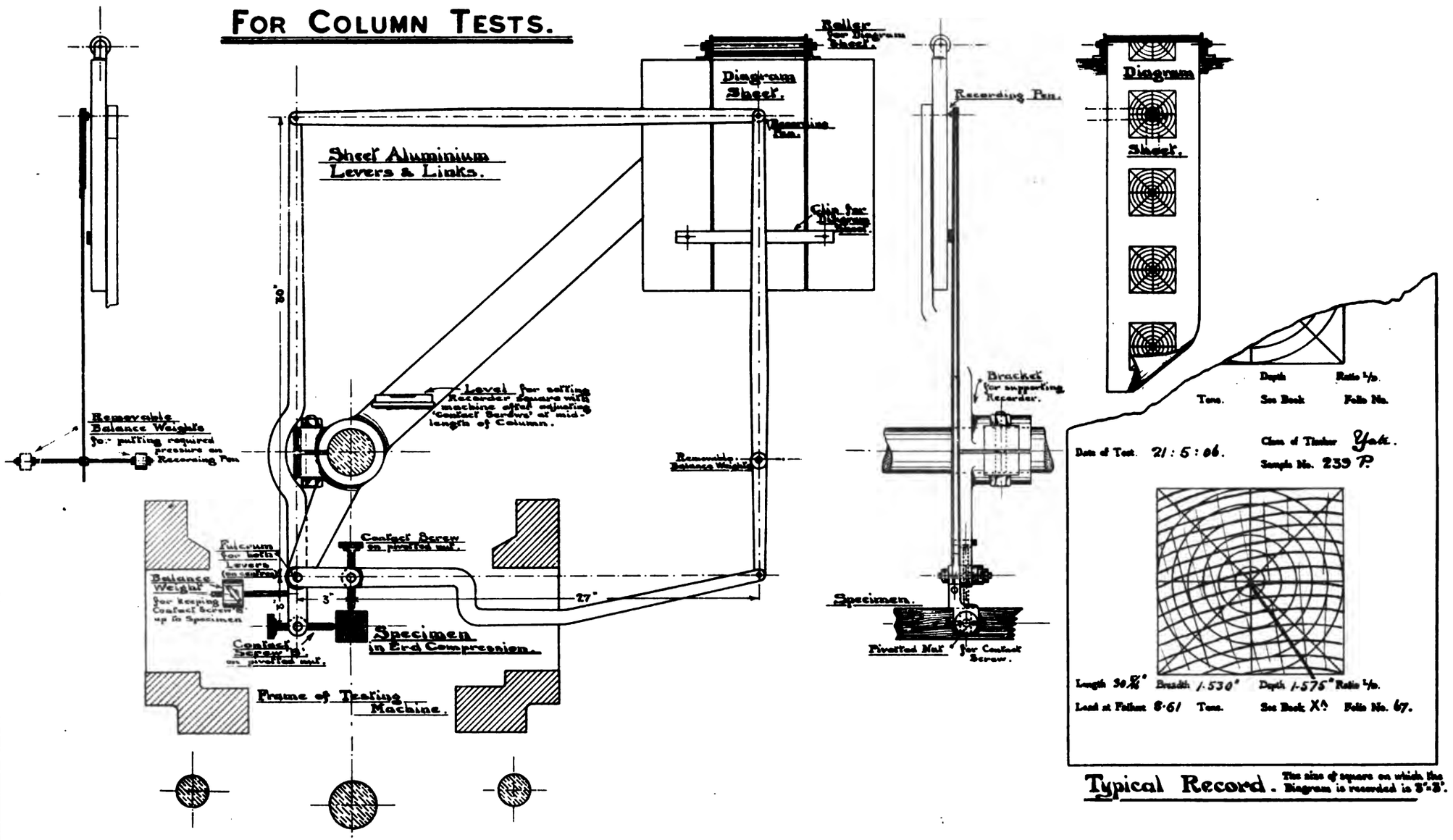


40-ton "Buckton" Universal Testing Machine.

AUTOGRAPHIC DEFLECTION APPARATUS.

FOR COLUMN TESTS.

W.A. Timber Tests.



Typical Record. The size of square on which the Diagram is recorded is 3"×3".

Plate No. 16

AUTOMATIC "DEFORMATION" RECORDER.

W.A. Timber Tests.

FOR 'CROSS COMPRESSION' & 'PENETRATION' TESTS.

See Appendix No. 3.

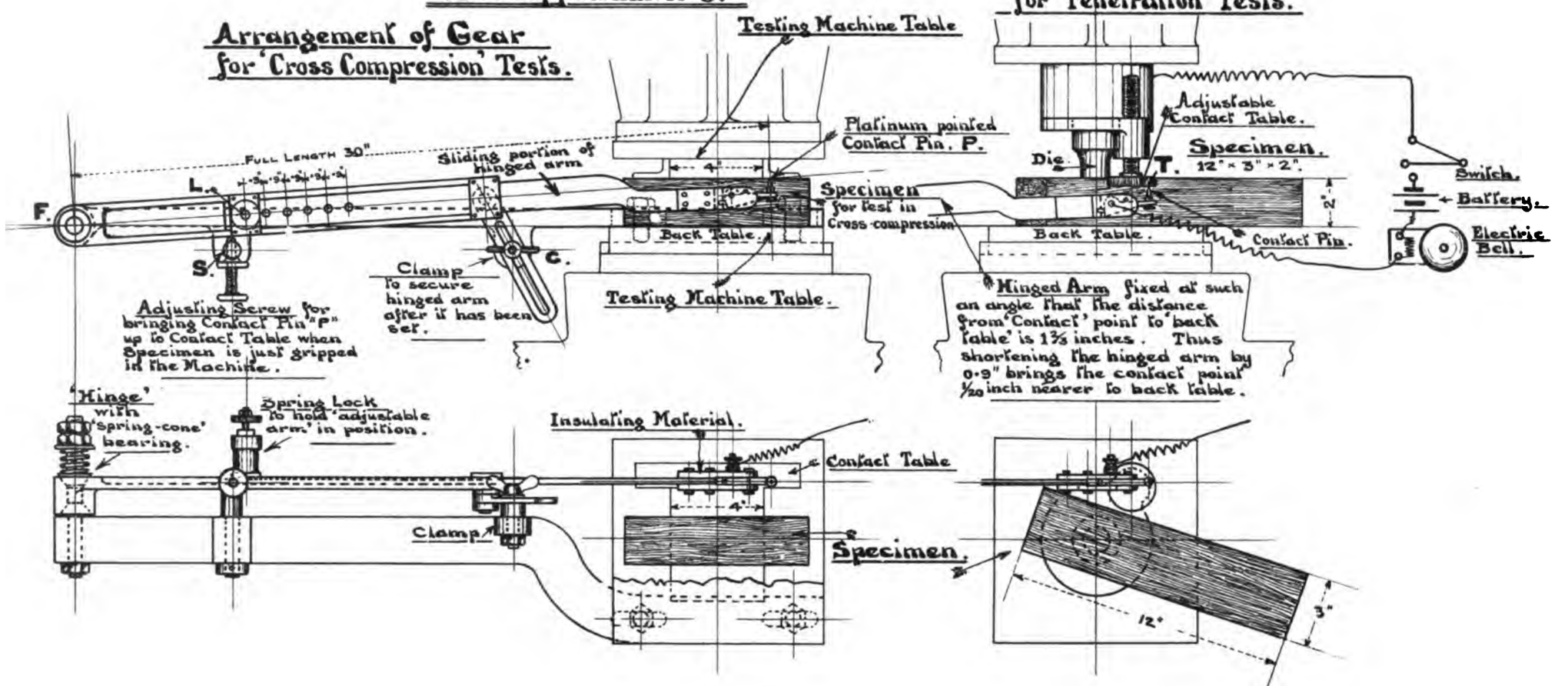
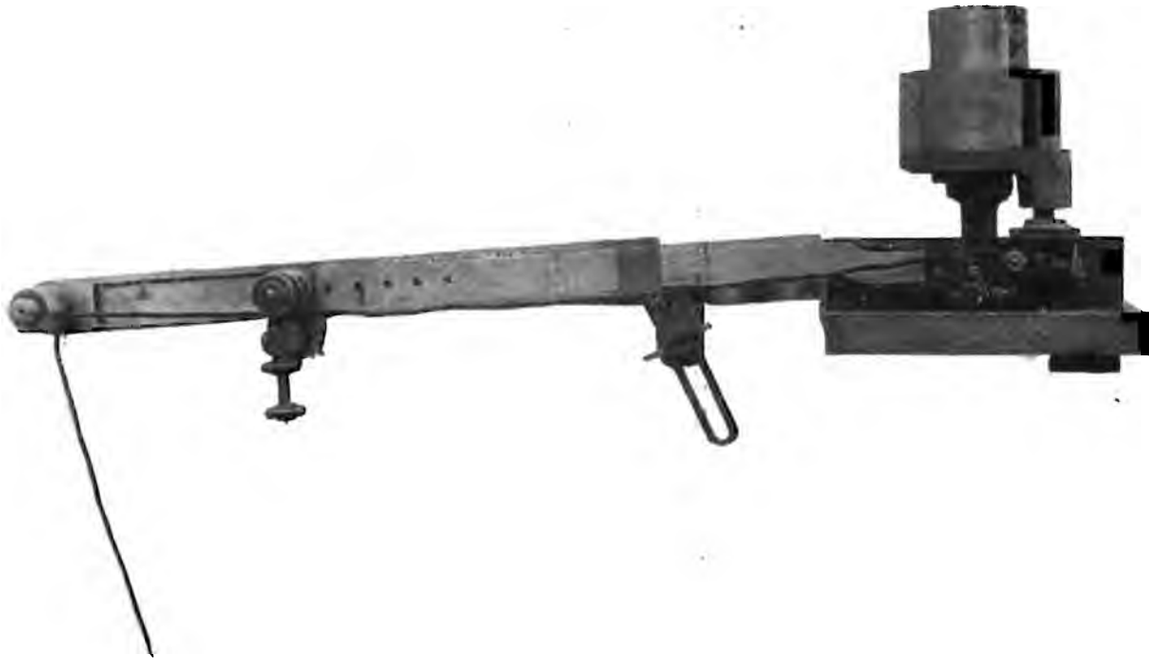


Plate No 17.

W.A. TIMBER TESTS, 1906.

AUTOMATIC APPLIANCE FOR RECORDING "DEPTHS" OF INDENTATION, ETC., AND PERCENTAGE DEFORMATION.

As "Set" for recording percentage Deformation in Cross Compression Tests.



As "Set" for recording Depths of Indentation in "Penetration" Tests.

See Appendix No. 3.

AUTOCRAPHIC STRESS STRAIN APPARATUS.

FITTED TO 40 TON TESTING MACHINE.

See Appendix No 1.

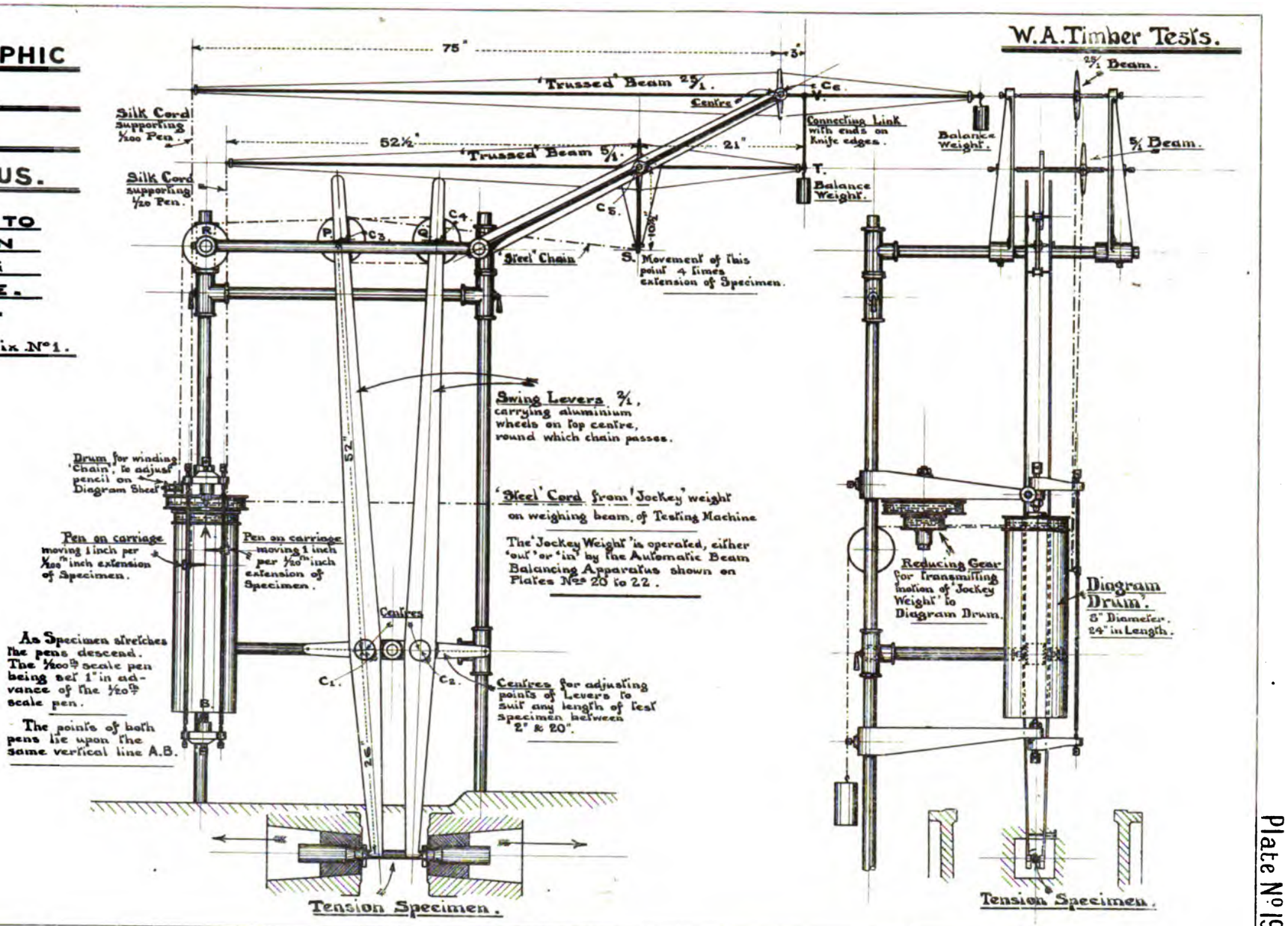


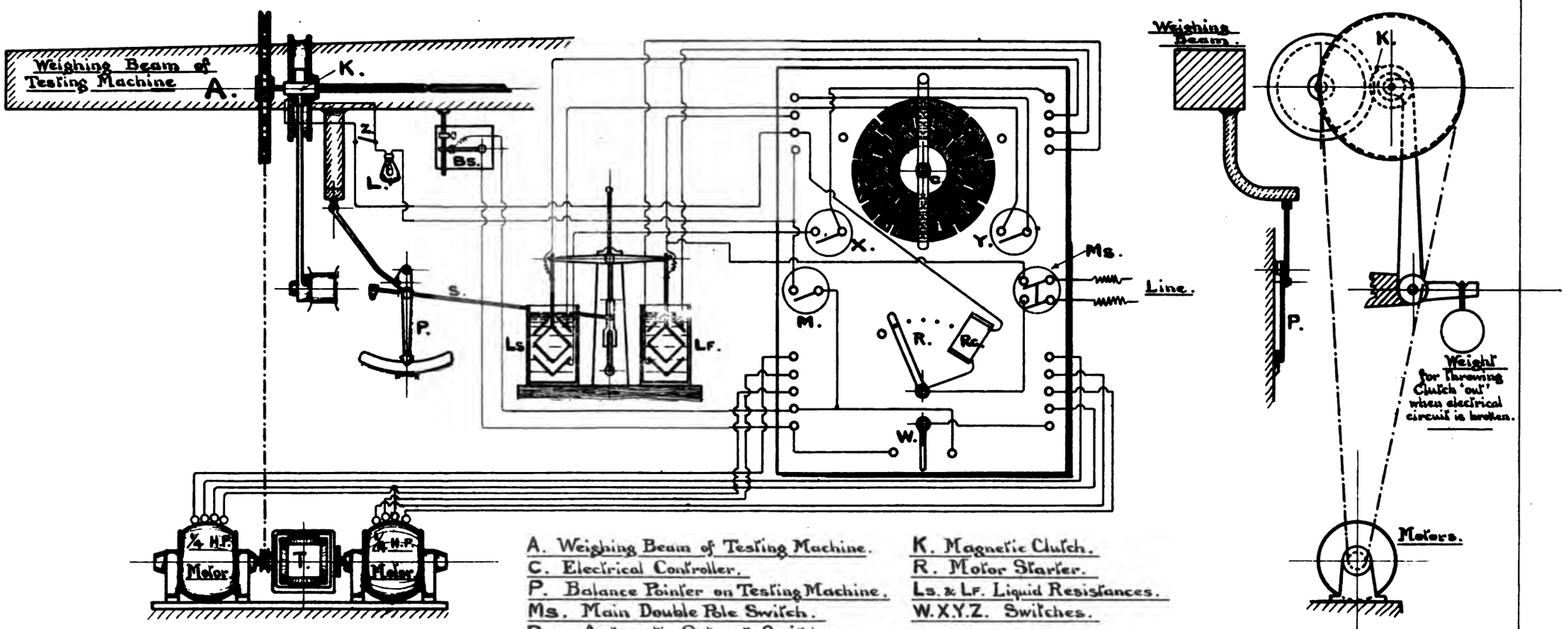
Plate No 19

AUTOMATIC ELECTRICAL APPARATUS.

For operating the 'Jockey Weight' upon the Weighing Beam of Testing Machine.

W.A. Timber Tests.
1906.

Arrangement.



A. Weighing Beam of Testing Machine.
C. Electrical Controller.
P. Balance Pointer on Testing Machine.
Ms. Main Double Pole Switch.
Bs. Automatic Cut-out Switch.
T. Epicycloid Train of Wheels.
S. Rod from Pointer P. to operate Liquid Resistances.
K. Magnetic Clutch.
R. Motor Starter.
Ls. & Lf. Liquid Resistances.
W.X.Y.Z. Switches.

Plate No. 20.

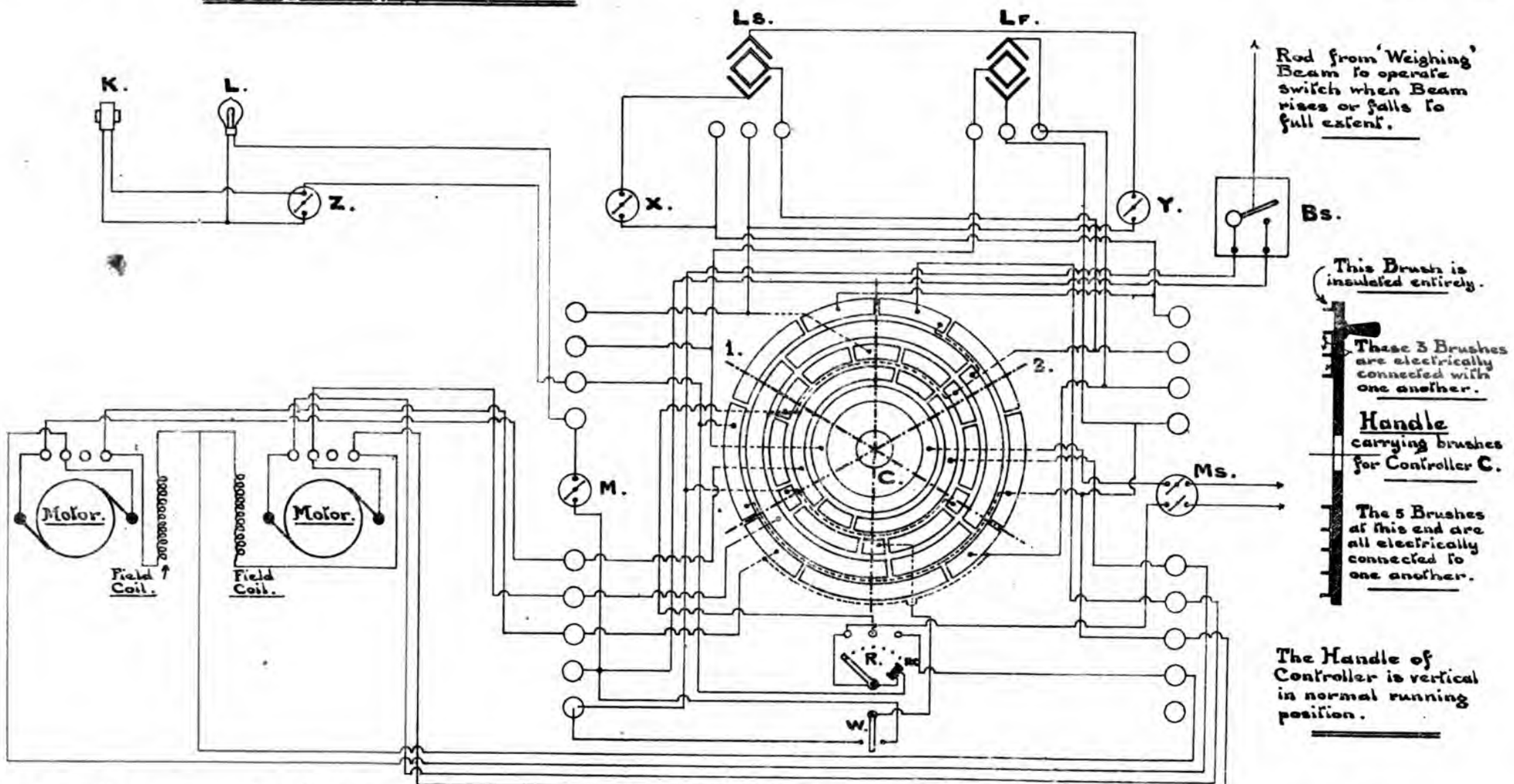
AUTOMATIC ELECTRICAL APPARATUS

For operating the 'Jockey Weight' upon the Weighing Beam of Testing Machine.

W.A. Timber Tests.

1906.

Diagram of Connections.



C. Controller.
Ms. Main Switch.

Bs. Automatic Switch.
M.W.X.Y. & Z Switches.

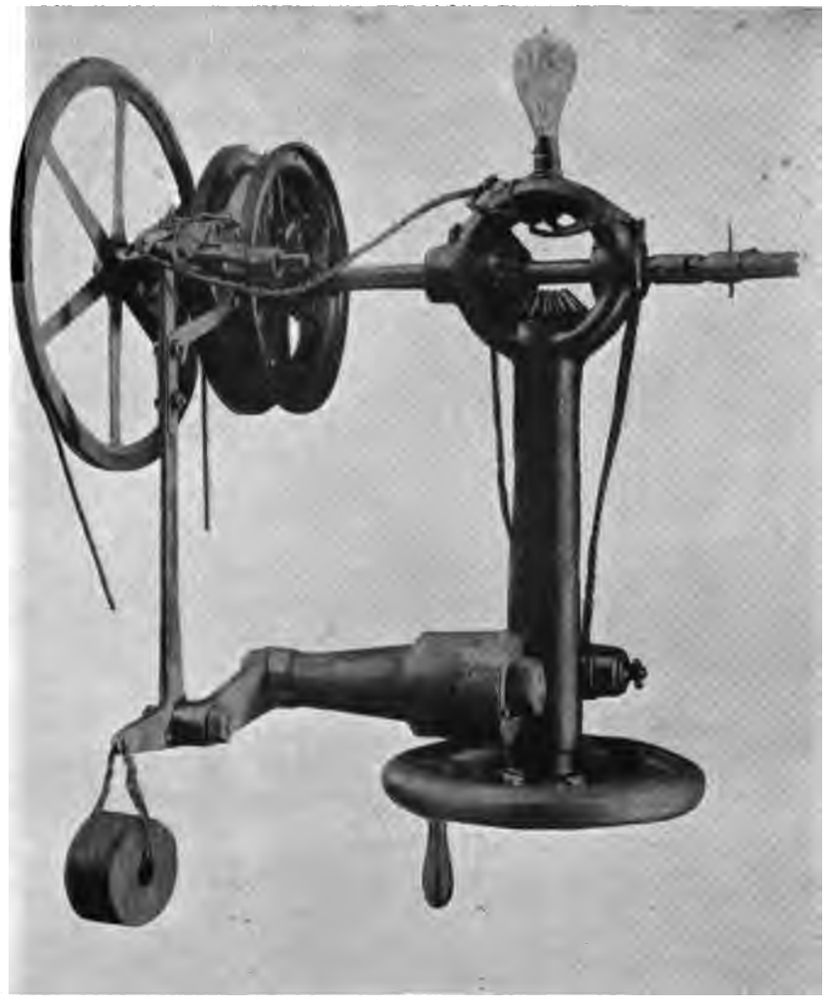
R. Motor Starter.
Rc. 'Retaining' Coil on Motor Starter.

Ls. Liquid Resistance in Armature Circuit.
Lf. Liquid Resistance in Field Coil Circuit.

Plate No 20A.

W.A. TIMBER TESTS, 1906.

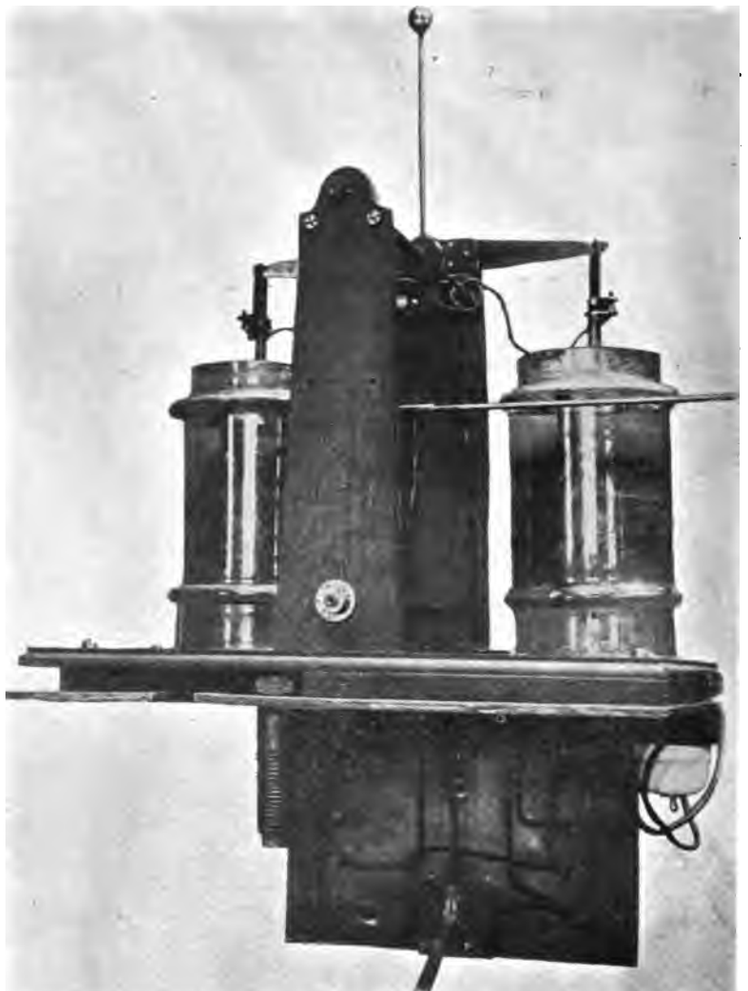
AUTOMATIC BEAM-BALANCING MECHANISM FITTED TO 40-TON TESTING MACHINE.



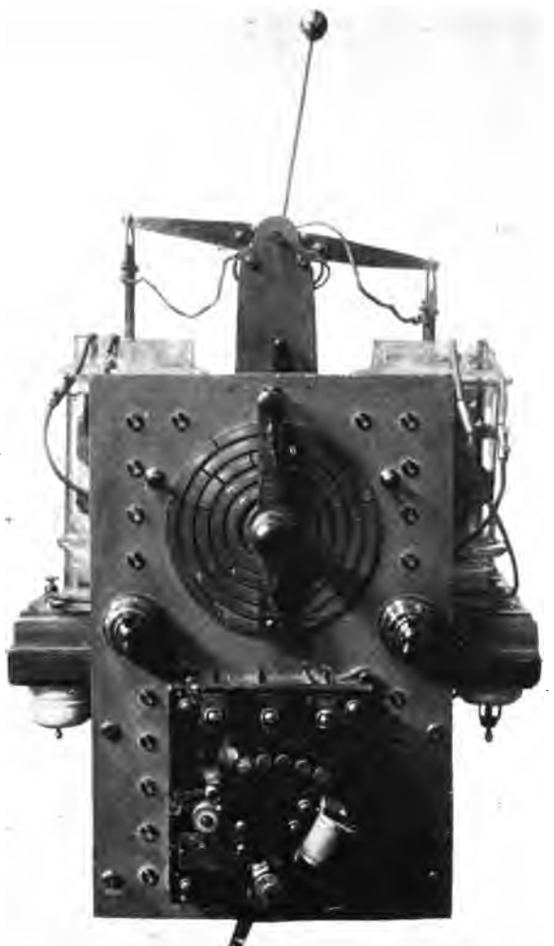
ELECTRICAL "CLUTCH" FOR AUTOMATICALLY ENGAGING "BEAM-BALANCING" MECHANISM TO "JOCKEY" WEIGHT TRAVERSING GEAR.

TWO ¼-H.P. ELECTRICAL MOTORS, WITH INTERMEDIATE "EPICYCLIC" TRAIN OF GEARING.

AUTOMATIC "BEAM BALANCING" MECHANISM FITTED TO 40-TON TESTING MACHINE.
"LIQUID RESISTANCES," ETC.



Back View



Front View.

See Appendix No. 2.

W.A. TIMBER TESTS, 1906.

"SHEARING" TESTS. STANDARD METHOD.

Appliance for holding Specimen, with Specimen in place.

N.B.—The "prepared" sample shows the "mortise" holes in planes at right angles to one another.

The specimen in "place" in the clips has portion of one face removed to show the cotter and self-adjusting steel piece.

W.A. TIMBER TESTS, 1906.

"SHEARING" TESTS. SYDNEY UNIVERSITY METHOD.

APPLIANCE FOR HOLDING THE SPECIMEN, WHICH IS SHOWN IN "PLACE."

N.B. The steel sliding surfaces are polished and well lubricated, and the width of specimen adjusted to exactly fill the required space.

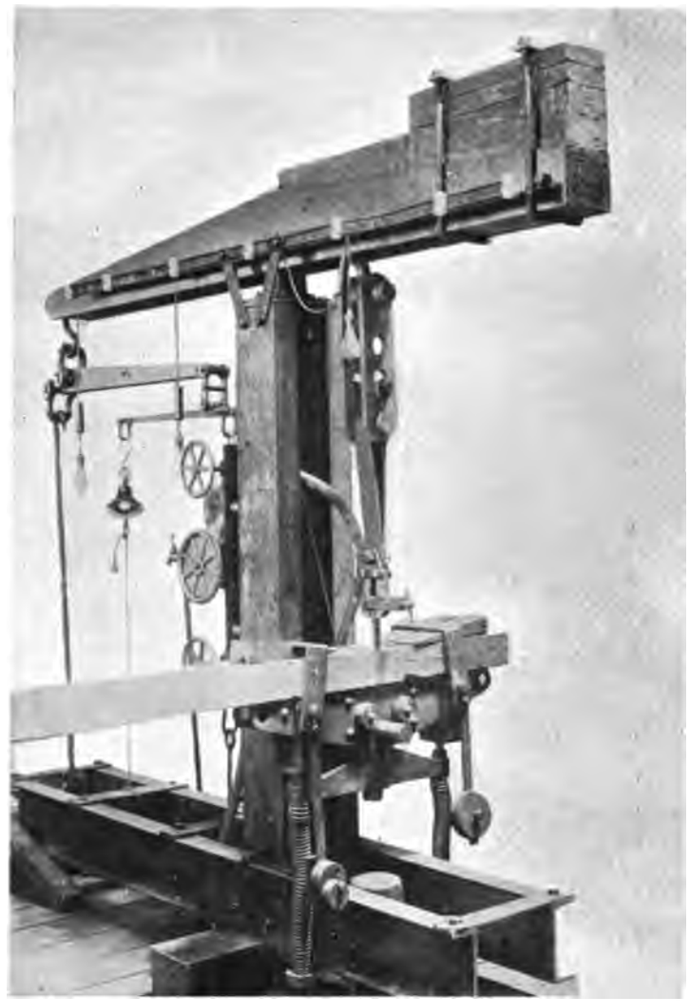
W.A. TIMBER TESTS, 1906.

TENSILE TESTS.

The upper illustration shows a test specimen in place in the "grips."

The middle and lower illustrations show end and side views of a tested specimen, in which the reduced portion has pulled through one of the enlarged ends, the specimen thus failing by "shearing" along the grain and not in "tension."

W.A. TIMBER TESTS, 1906.



MACHINE USED TO DETERMINE THE HOLDING POWER OF "DOG SPIKES."

TYPES OF "DOG SPIKES" TESTED.

W.A. TIMBER TESTS, 1906.

SECTION THROUGH "JARRAH" PILE DRAWN AFTER OVER 70 YEARS' SERVICE IN THE SWAN RIVER.

"JARRAH" PILE AFTER 70 YEARS' SERVICE IN THE SWAN RIVER.

SECTION THROUGH "JARRAH" PILE AFTER 18 YEARS' SERVICE IN SALT WATER AT FREMANTLE.

NOTE.—Holes bored by marine insects in the Sapwood only.

"Tuart" Wagon Bogie Bolster, after 14 years' service.
These bolsters are at present thoroughly sound, and have not shrunk or twisted, although "put in" when green.

"Teak" Wagon Bogie Bolster, after 8 years' service (average life). Badly split.

"American Oak" Wagon Bogie Bolster, after 5 years' service (average life).
These bolsters never last more than eight years, and many have to be removed after four years' service.

W.A. TIMBER TESTS, 1906.

SECTION THROUGH "TUART" WAGON BOGIE BOLSTER, AFTER 14 YEARS' SERVICE.

SECTION THROUGH "AMERICAN OAK" WAGON BOGIE BOLSTER, AFTER 7 YEARS' SERVICE.

Both the above sections are taken through the Bogie Centre pin hole. The "Tuart" bolster was from the "Heart" wood.

W.A. TIMBER TESTS, 1906.

SECTION THROUGH "TUART" WAGON BOGIE BOLSTER, AFTER 14 YEARS' SERVICE.

SECTION THROUGH "TEAK" WAGON BOGIE BOLSTER, AFTER 8 YEARS' SERVICE.

Both the above sections are taken through the bogie centre bolt holes.

W.A. TIMBER TESTS, 1906.

SECTION THROUGH "TUART" BOGIE WAGON BOLSTER, AFTER 14 YEARS' SERVICE.

SECTION THROUGH "AMERICAN OAK" WAGON BOGIE BOLSTER, AFTER 6 YEARS' SERVICE.

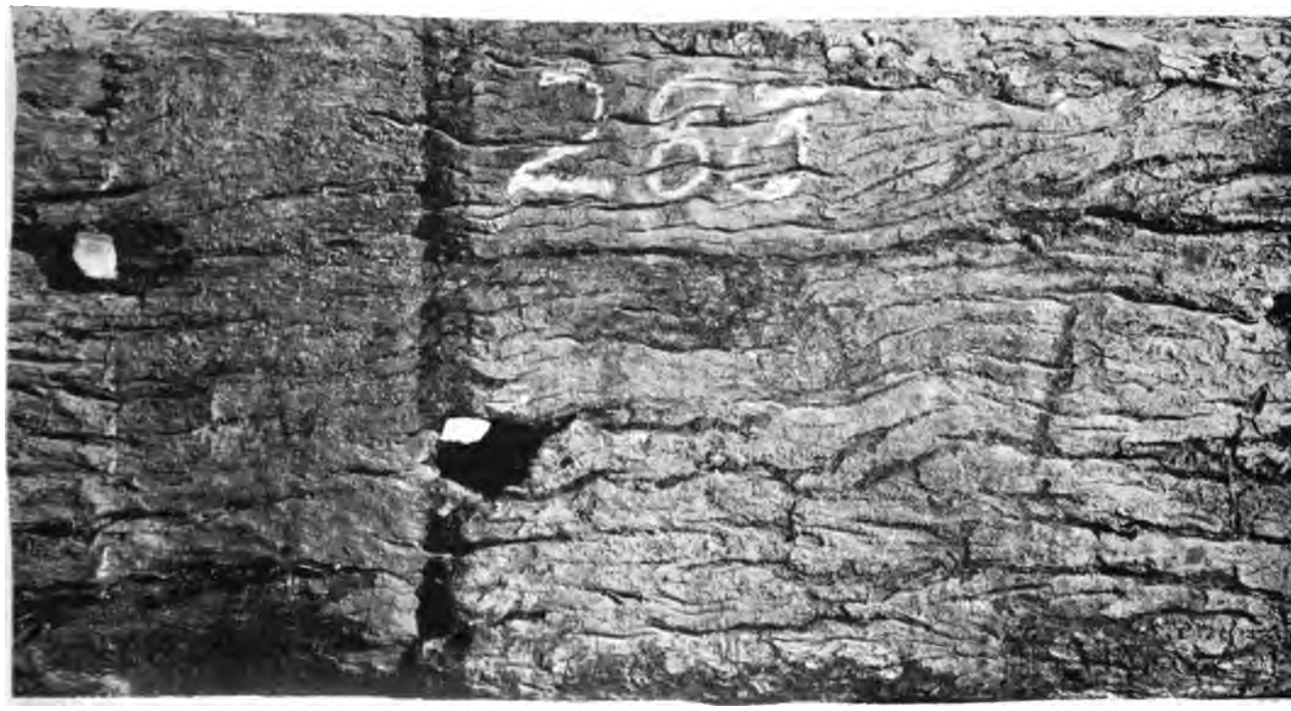
Both the above Bolsters were cut from "Heart" wood.

W.A. TIMBER TESTS, 1906.

PHOTOGRAPHS OF "SURFACE" AND "SECTIONS" OF A SLEEPER OF "WANDOO" (E. REDUNCA), SHOWING AVERAGE CONDITION AFTER 18 YEARS' SERVICE IN "DIRTY" GRAVEL BALLAST.

N.B.—Many of these sleepers were tested in "cross bending," and gave results 6 per cent. only below those obtained with unused seasoned timber. The average pull required to draw the "spikes" was 3,403lbs.

W.A. TIMBER TESTS, 1906.



PHOTOGRAPHS OF "SURFACE" AND "SECTIONS" OF A SLEEPER OF "WANDOO" (E. REDUNCA), SHOWING AVERAGE CONDITION AFTER 18 YEARS' SERVICE IN "DIRTY" GRAVEL BALLAST.

W.A. TIMBER TESTS, 1906.

PHOTOGRAPHS OF "SURFACE" and "SECTIONS" OF A SLEEPER OF "WANDOO" (E. REDUNCA), SHOWING AVERAGE CONDITION AFTER 8 YEARS' SERVICE.

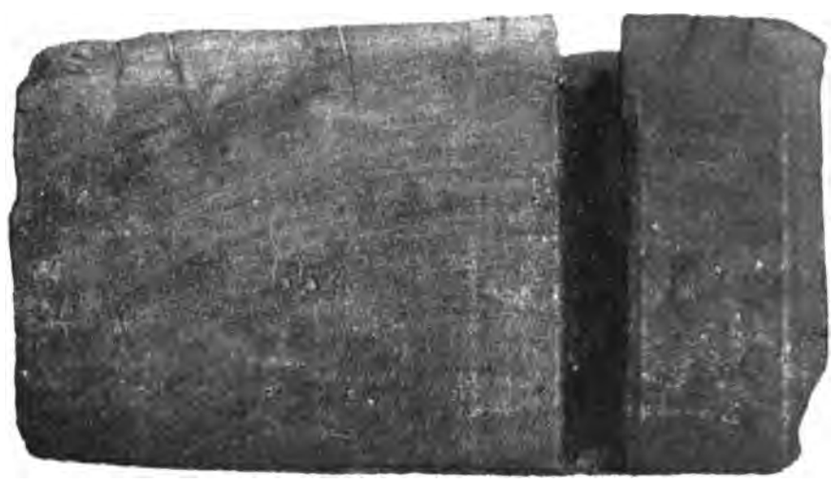
N.B. - Average pull required to draw the original "Spikes" was 4,462lbs.

W.A. TIMBER TESTS, 1906.

PHOTOGRAPHS OF "KARRI" SLEEPERS, AFTER 19 YEARS' SERVICE IN DAMP COUNTRY.

The average pull required to draw the spikes was 3,300lbs.

W.A. TIMBER TESTS, 1906.



PHOTOGRAPHS OF "SURFACE" AND "SECTIONS" OF A SLEEPER OF JARRAH (E. MARGINATA), SHOWING AVERAGE CONDITION AFTER 10 YEARS' SERVICE.

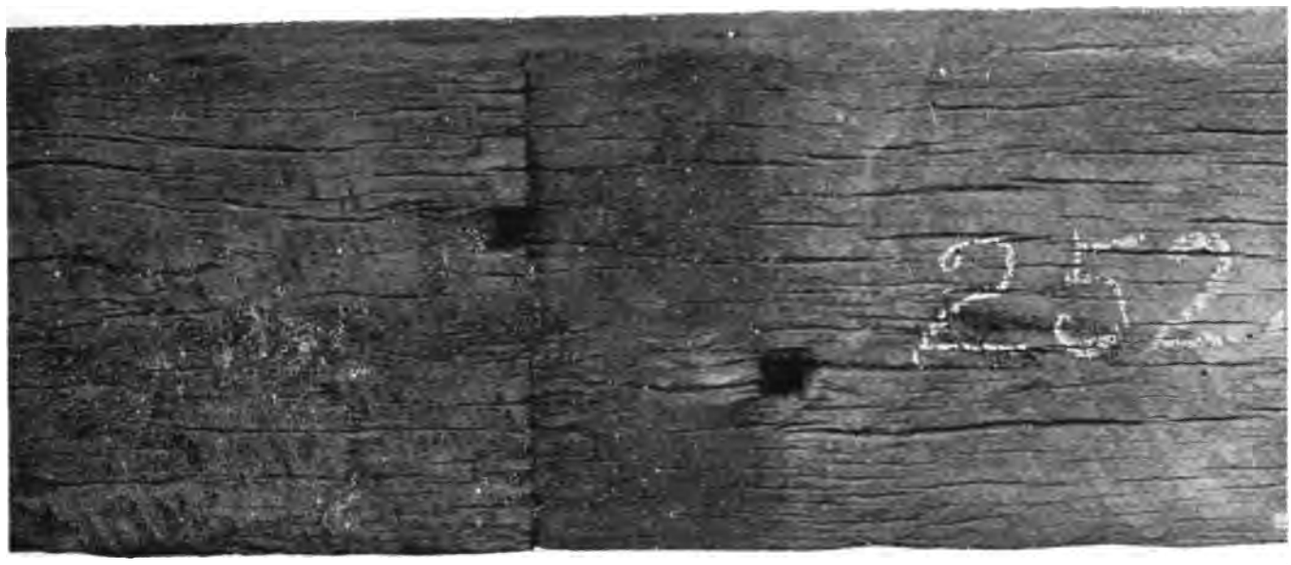
W.A. TIMBER TESTS, 1906.

"Jarrah" Sleeper, after 10 years' service, showing average condition.

W.A. TIMBER TESTS, 1906.

PHOTOGRAPHS OF "SURFACE" AND "SECTIONS" OF SLEEPER OF "BLACKBUTT" (E. PATENS), SHOWING AVERAGE CONDITION AFTER 4 YEARS' SERVICE.

W.A. TIMBER TESTS, 1906.



"Blackbutt" Sleeper, after 4 years' service in "Dirty" Gravel Ballast.
The average pull required to draw the "Spikes" was 3,046lbs.

W.A. TIMBER TESTS, 1906.

PHOTOGRAPHS OF "SURFACE" AND "SECTIONS" OF A SLEEPER OF "RED GUM" (E. CALOPHYLLA), SHOWING AVERAGE CONDITION AFTER 4 YEARS' SERVICE.

"Red Gum" Sleeper, after 4 years' service.

The pull required to "draw" the spikes from these Sleepers averaged 6,787lbs.

SLEEPER OF "JARRAH" (E. MARGINATA), AFTER 20 YEARS' SERVICE IN "DIRTY" GRAVEL BALLAST.

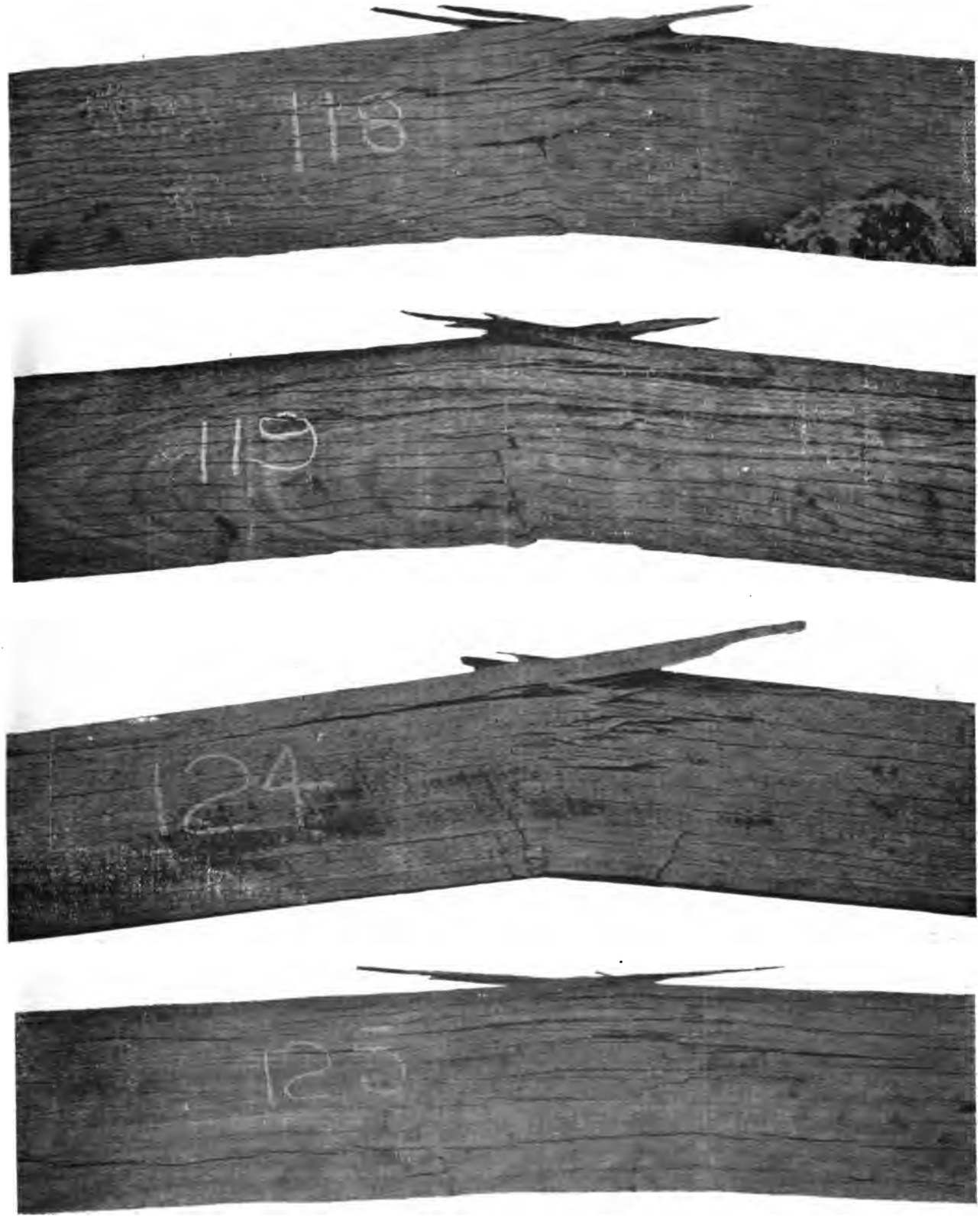
Used in a district with heavy rainfall for four months of the year, the remainder of the year being very hot and dry. The average pull required to "draw" the spikes was 1,809lbs.

PHOTOGRAPHS OF "SURFACE" AND "SECTIONS" OF A SLEEPER OF "JARRAH" (E. MARGINATA), AFTER 20 YEARS' SERVICE.

The "condition" of this and of other sleepers illustrated herewith represents an "average" of many sleepers of each variety drawn from the road without special selection.

W.A. TIMBER TESTS, 1906.

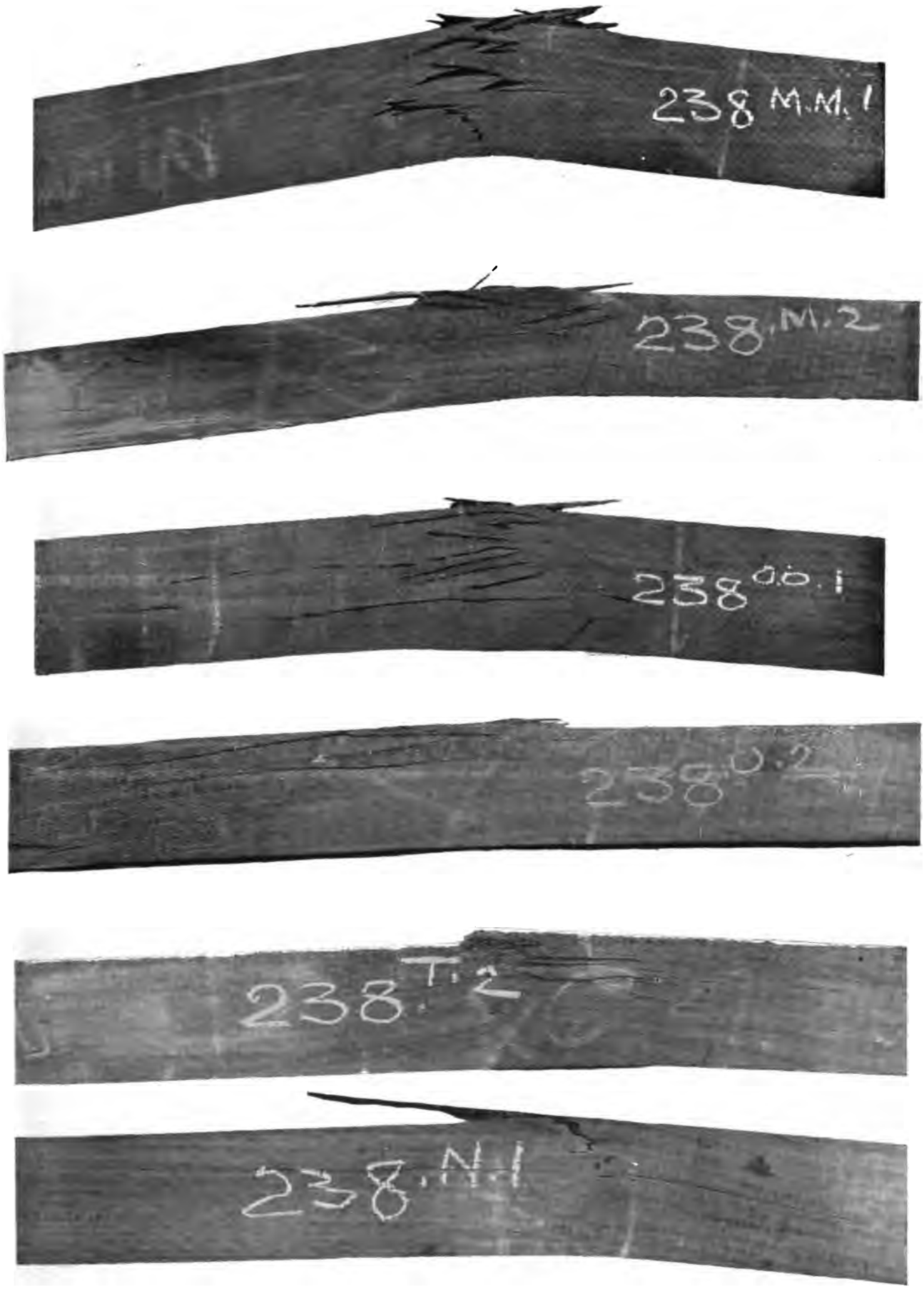
Cross Bending Tests.



Typical fractures of "Karri" (E. diversicolor). Material well seasoned.

W.A. TIMBER TESTS, 1906.

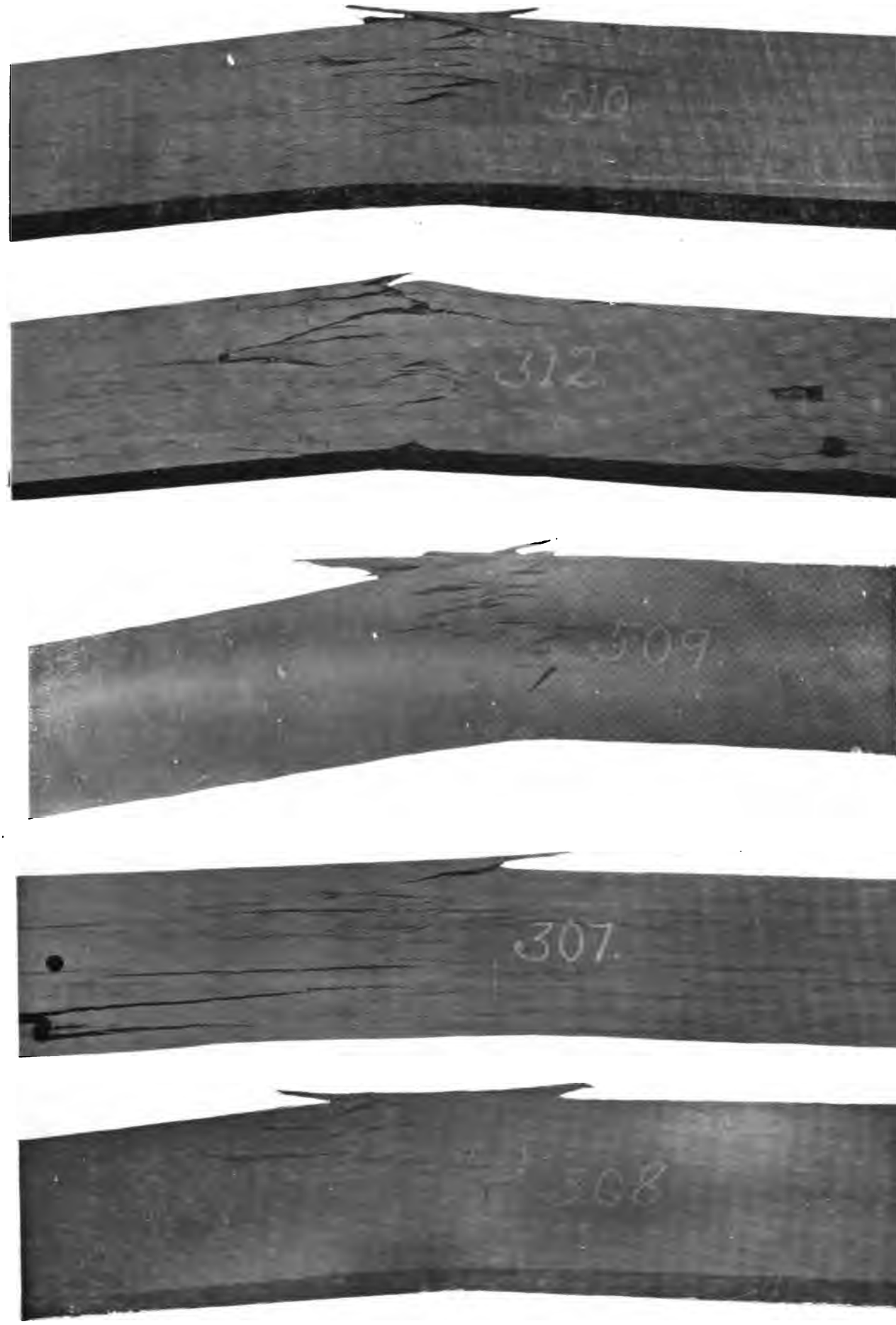
CROSS BENDING TESTS.



"TUART" (E. GOMPHOCEPHALA).

W.A. TIMBER TESTS, 1906.

Cross Bending Tests.



"Wandoo" (E. redunca).

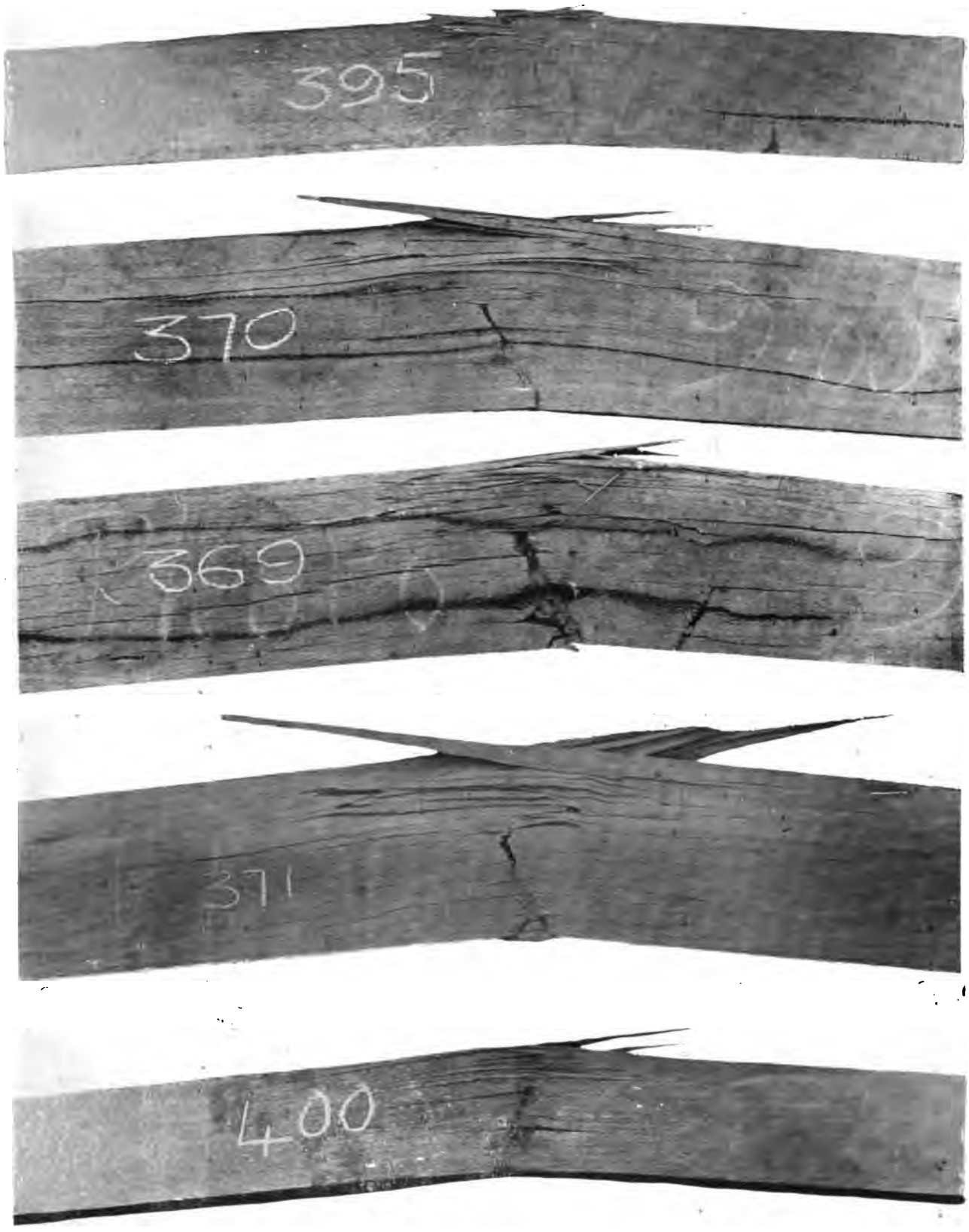
W.A. TIMBER TESTS, 1906.

Cross Bending Tests.

"Blackbutt" (E. patens).

W.A. TIMBER TESTS, 1906.

Cross Bending Tests.



"Red Gum" (E. calophylla).

W.A. TIMBER TESTS, 1906.

Cross Bending Tests.

"Yate" (E. cornuta).

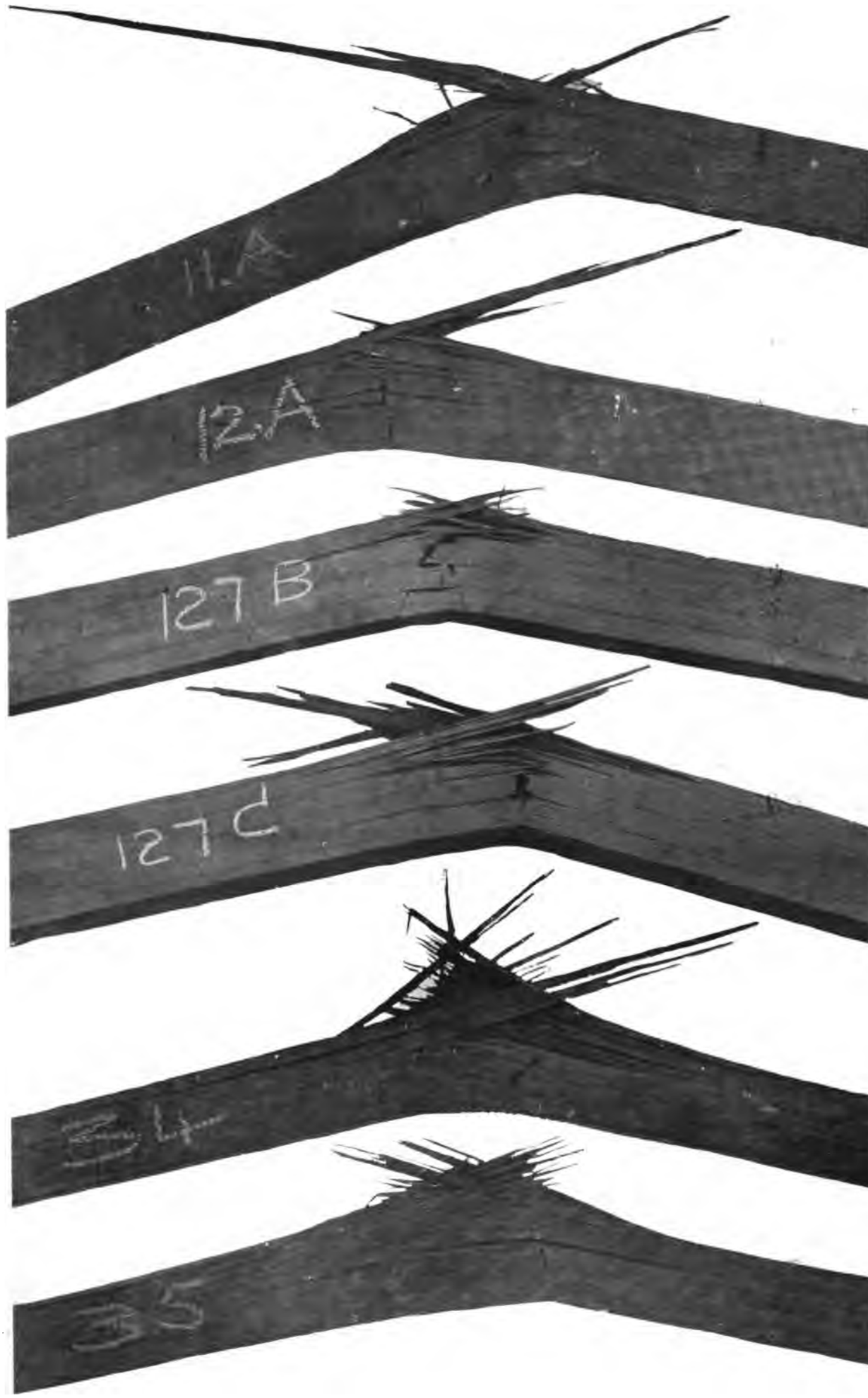
W.A. TIMBER TESTS, 1906.

CROSS BENDING TESTS.

"JARRAH" (E. MARGINATA).

W.A. TIMBER TESTS, 1906.

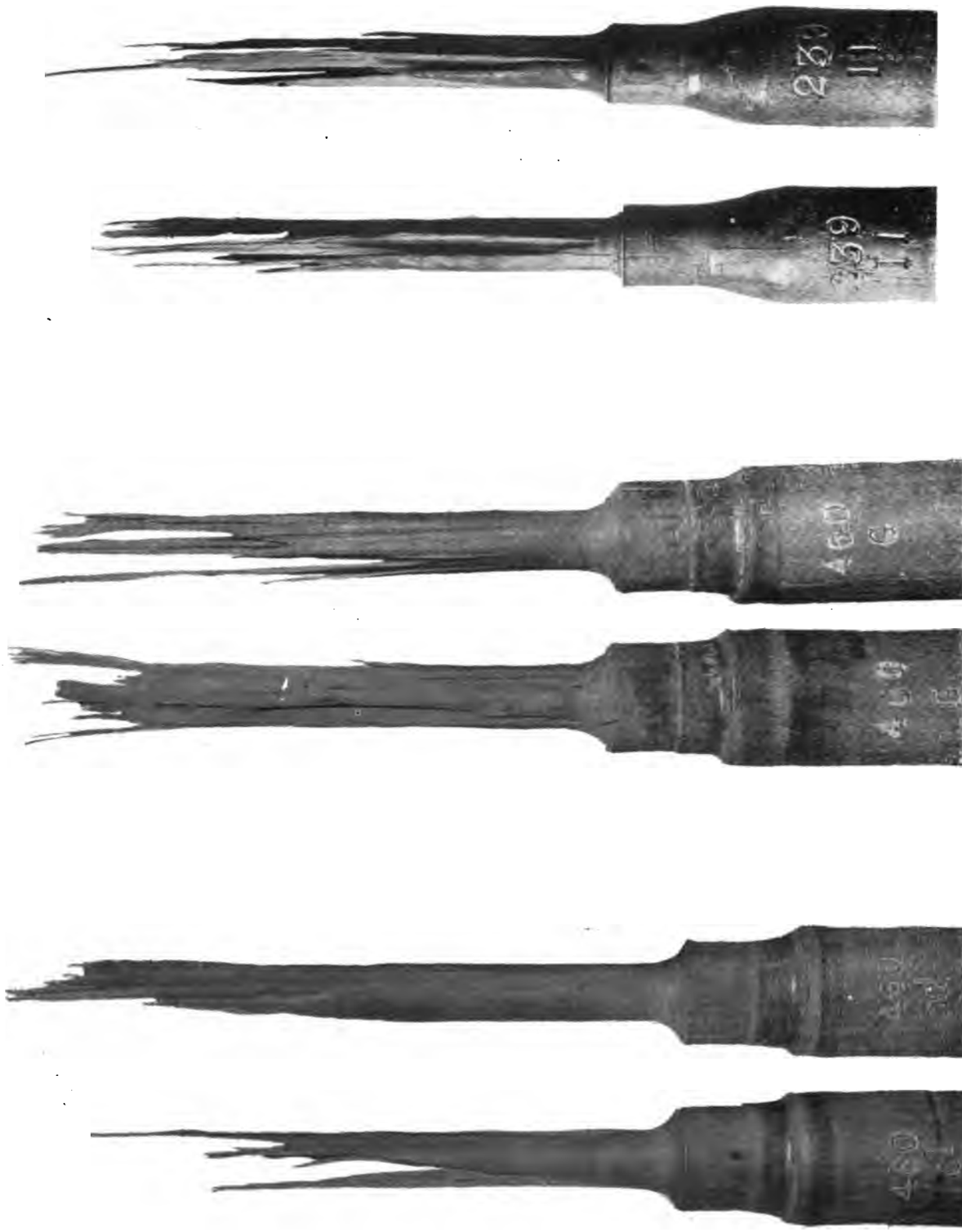
CROSS BENDING TESTS.



"KARRI" (E. DIVERSICOLOR).

W.A. TIMBER TESTS, 1906

TENSILE TESTS.



"YATE" (E. CORNUTA).

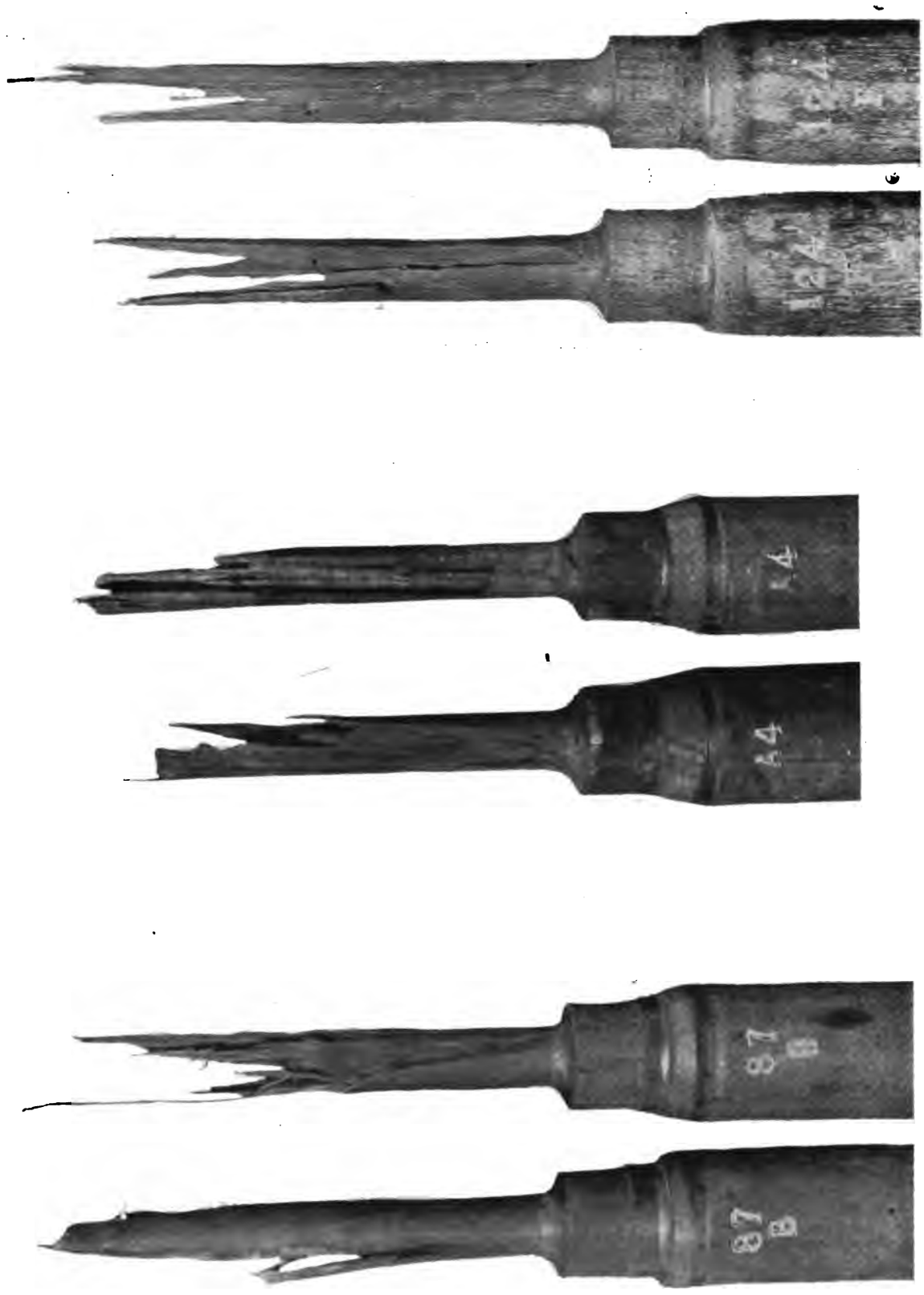
W.A. TIMBER TESTS, 1906.

TENSILE TESTS.

"JARRAH" (E. MARGINATA).

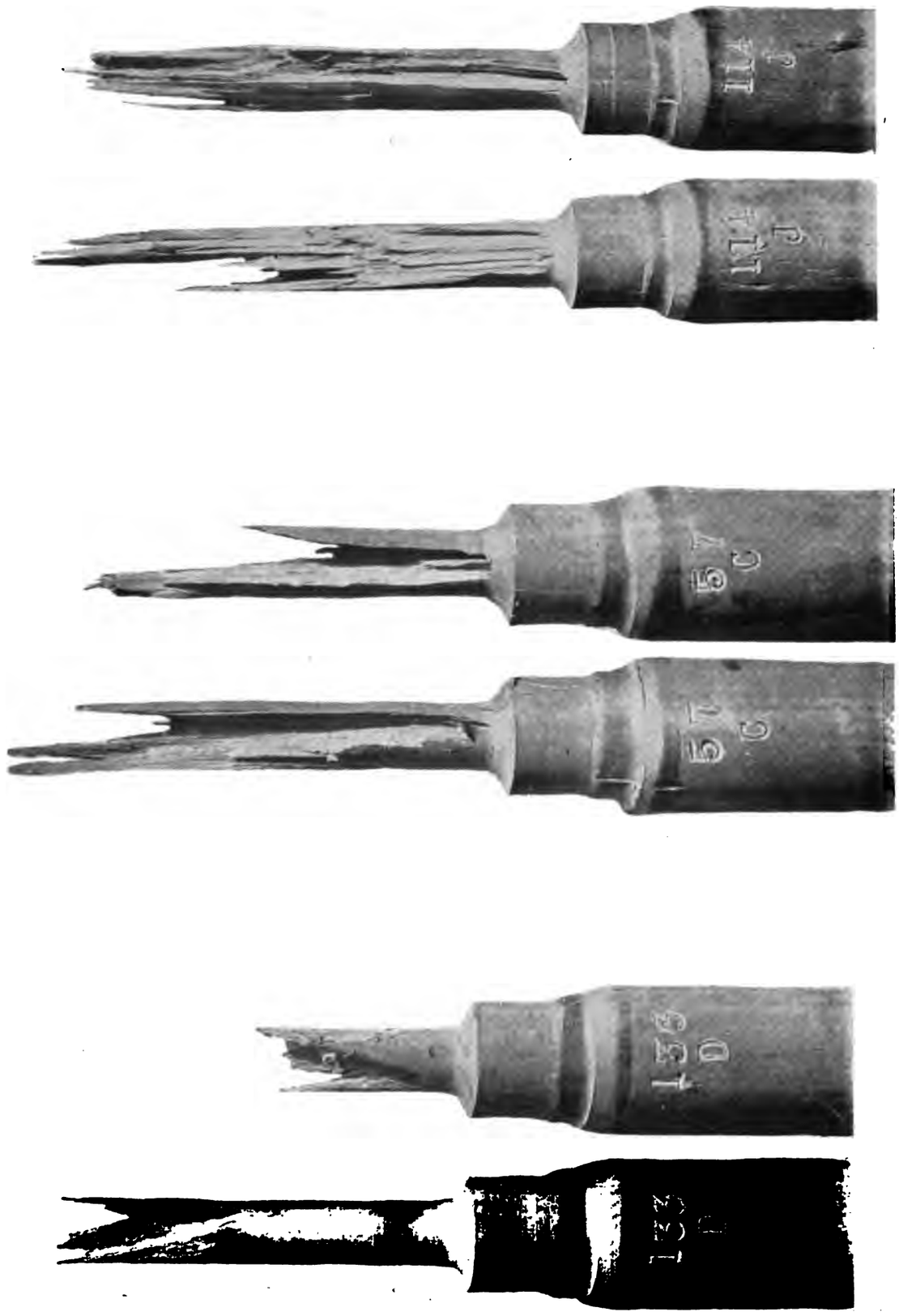
W.A. TIMBER TESTS, 1906.

TENSILE TESTS.



"KARRI" (E. DIVERSICOLOR).

W.A. TIMBER TESTS, 1906.

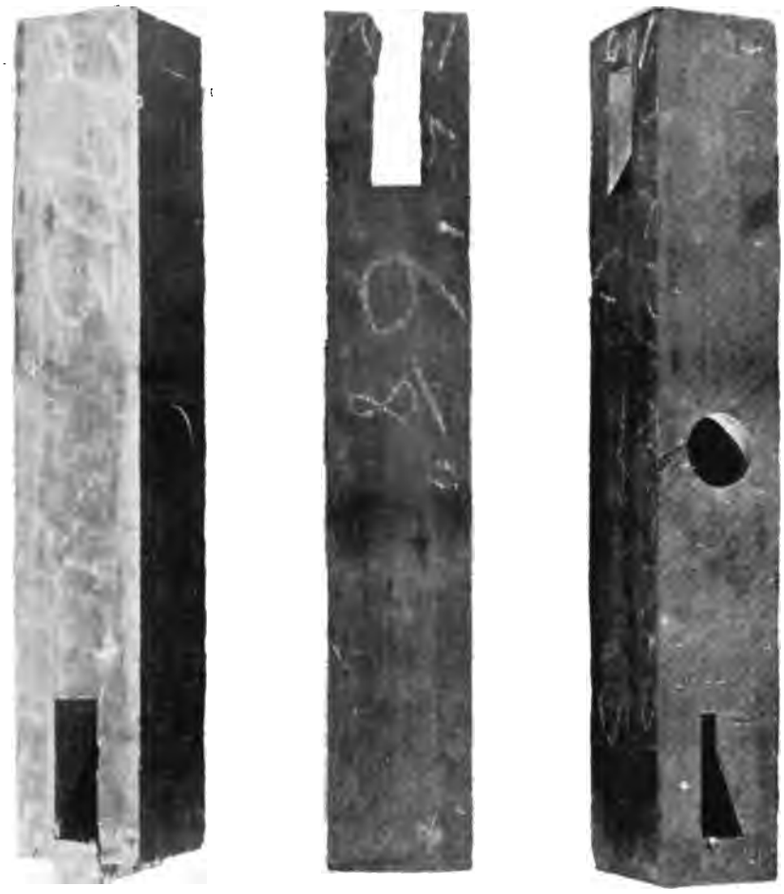


TENSILE TESTS.

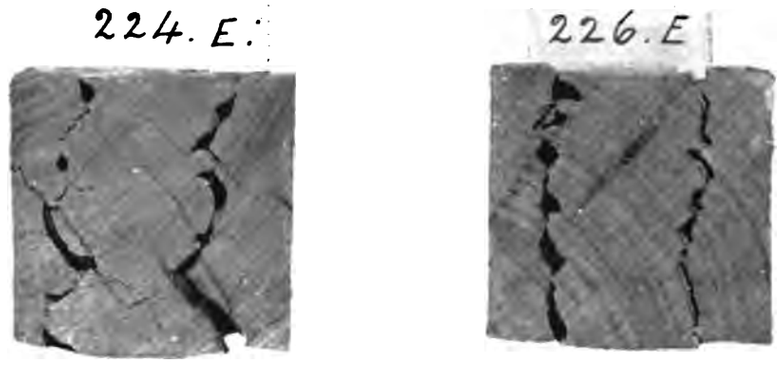
TYPICAL "TUART" FRACTURES (E. GOMPHOCEPHALA).

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Standard Method.



"Specimens" before and after Test.

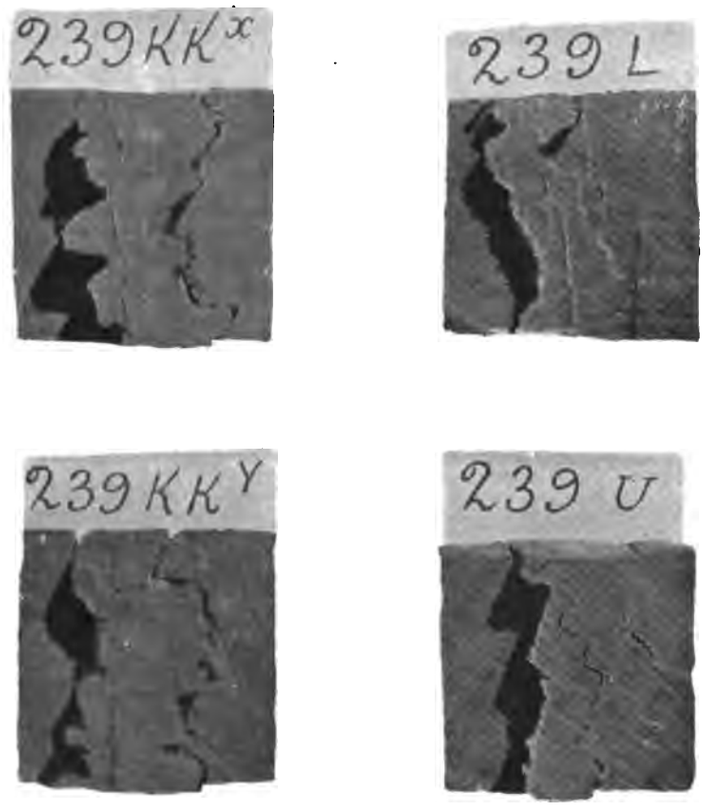


Typical failure of "York Gum"—end view (E. loxophleba).

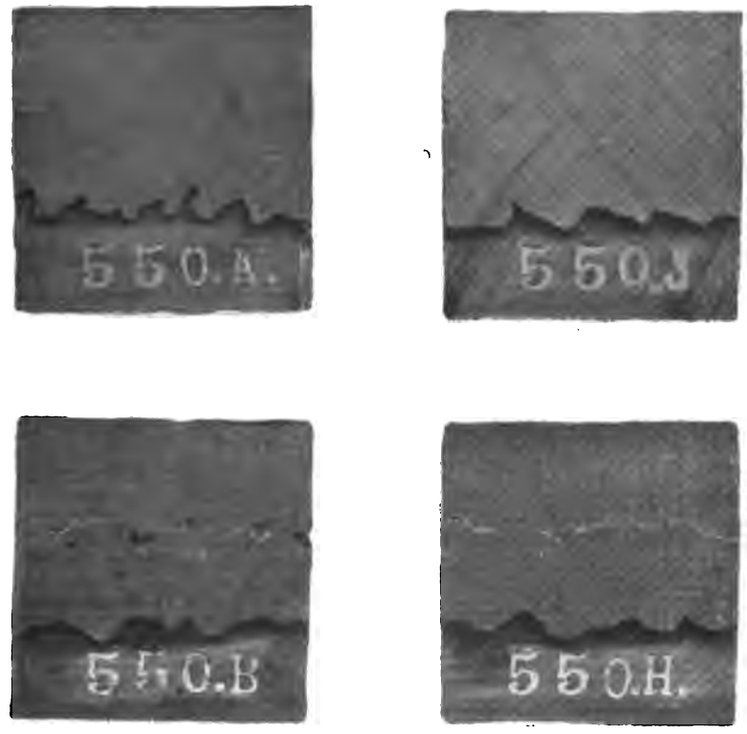
"Morrell" (E. longicornis).

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Standard Method.



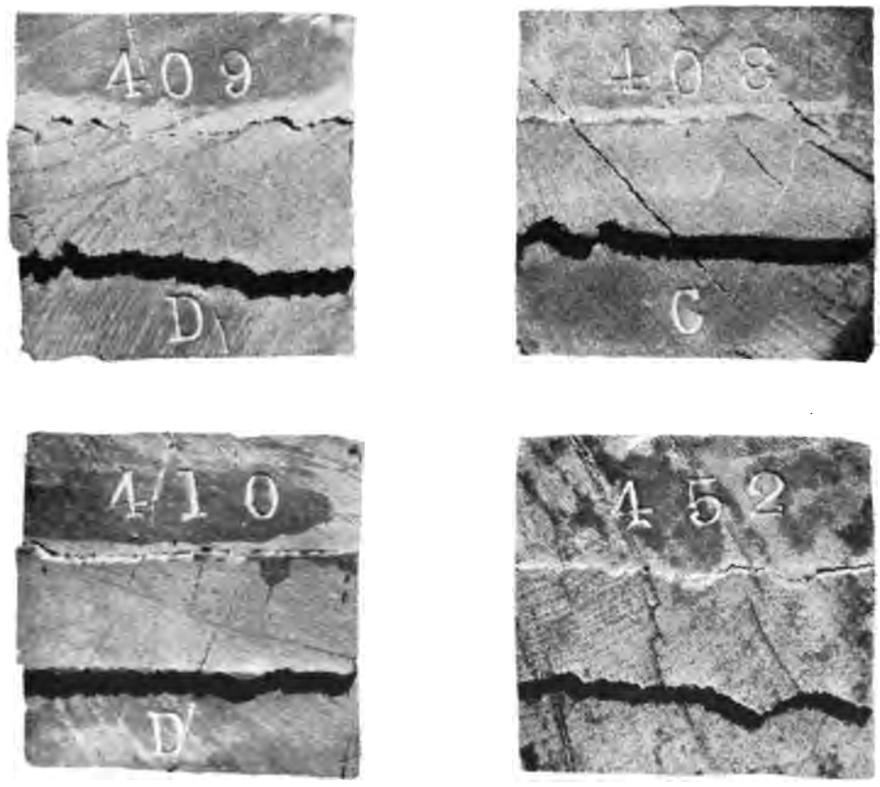
Typical Fractures—"Yate" (E. cornuta).



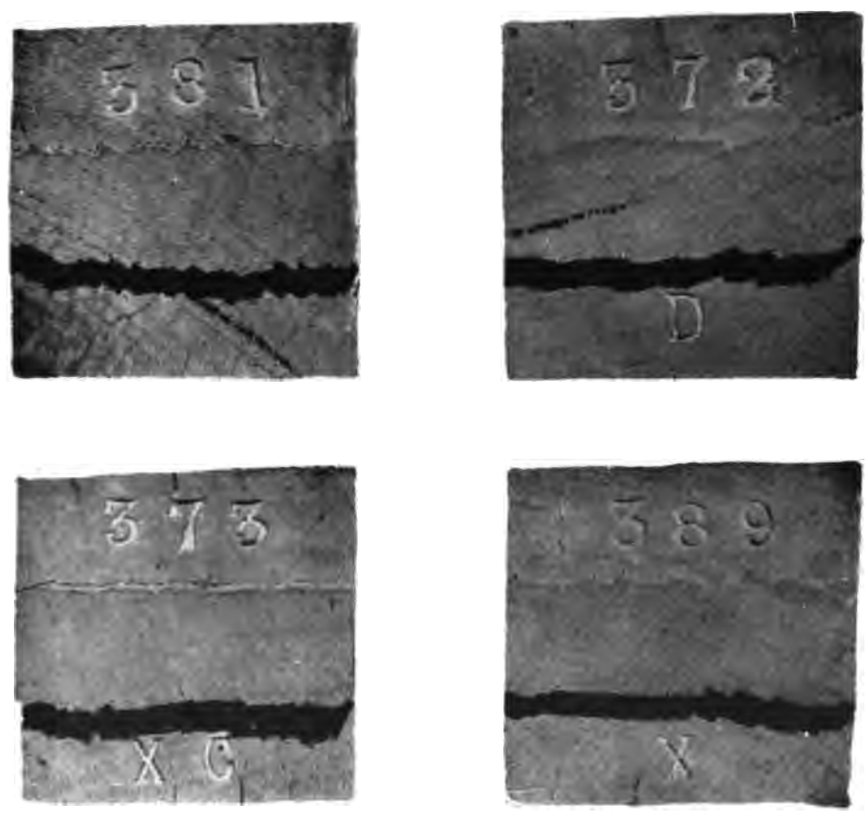
"Tuart" (E. gomphocephala).

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Standard Method.



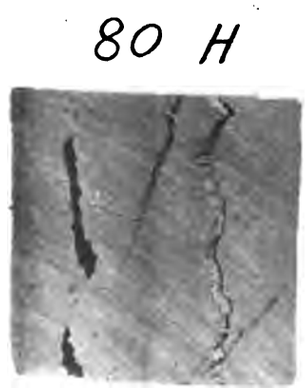
"Blackbutt" (E. patens).



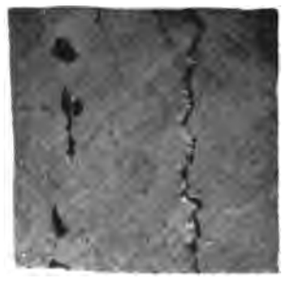
"Red Gum" (E. calophylla).

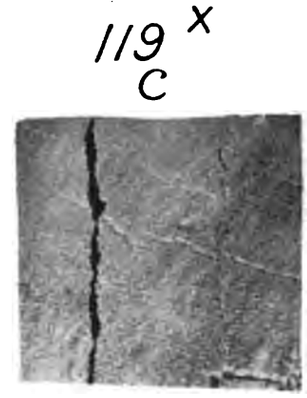
W.A. TIMBER TESTS, 1906.

"SHEARING" TESTS. STANDARD METHOD.



"JARRAH" (E. MARGINATA).

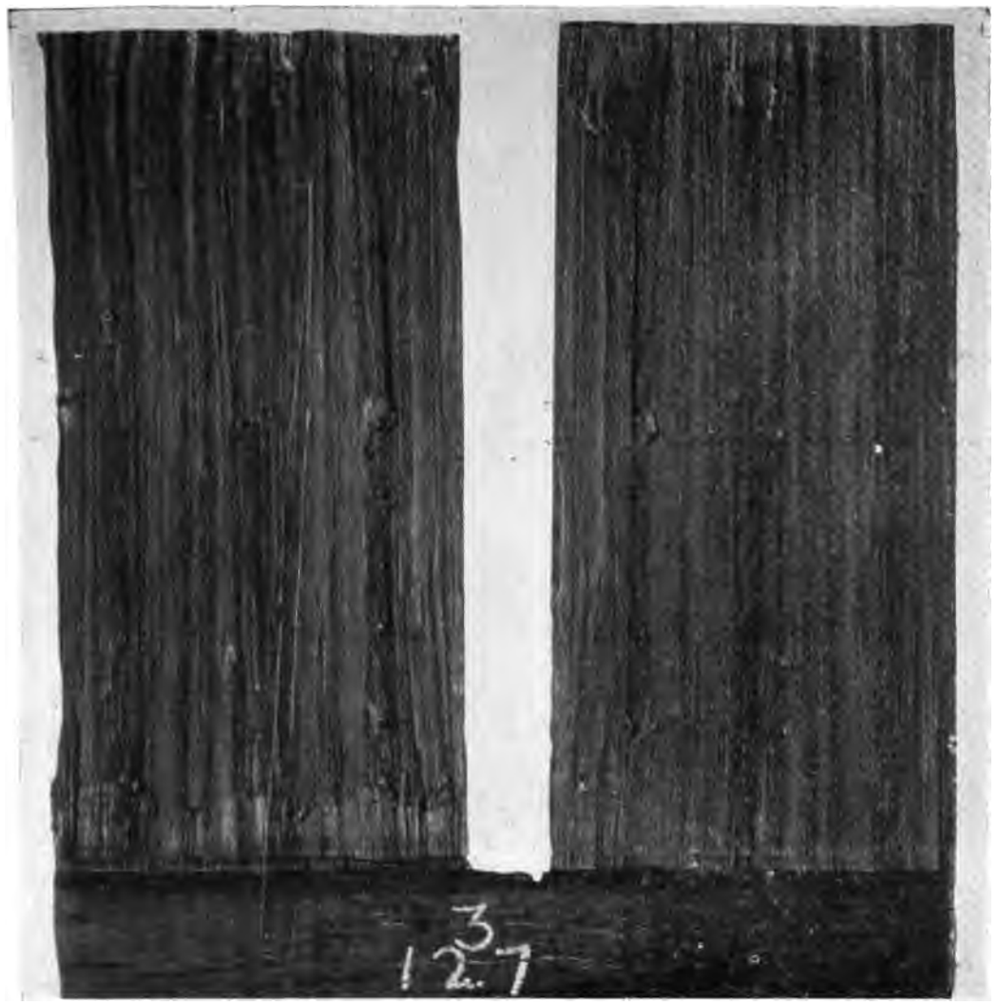




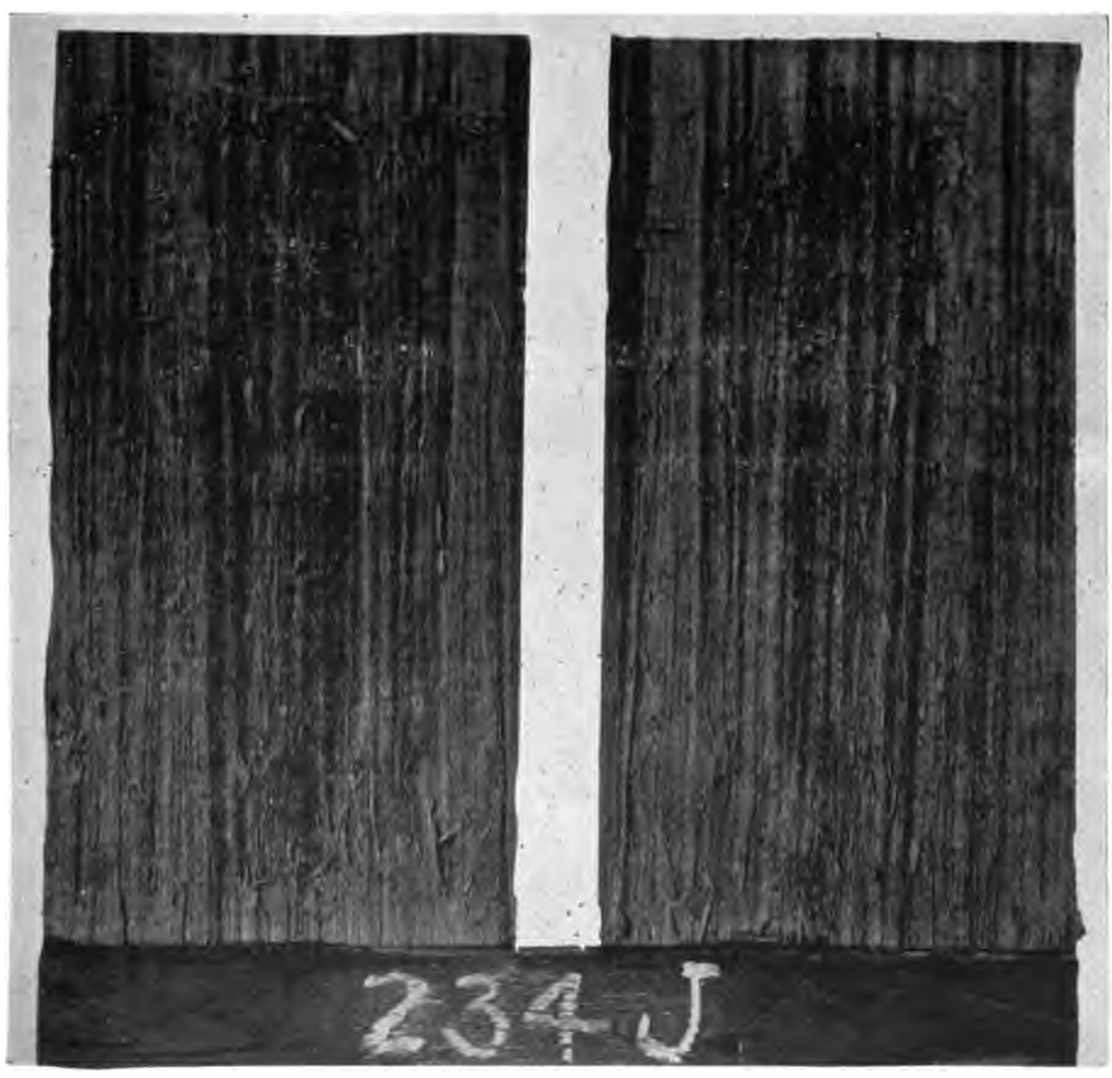
"KARRI" (E. DIVERSICOLOR).

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Sydney University Method.



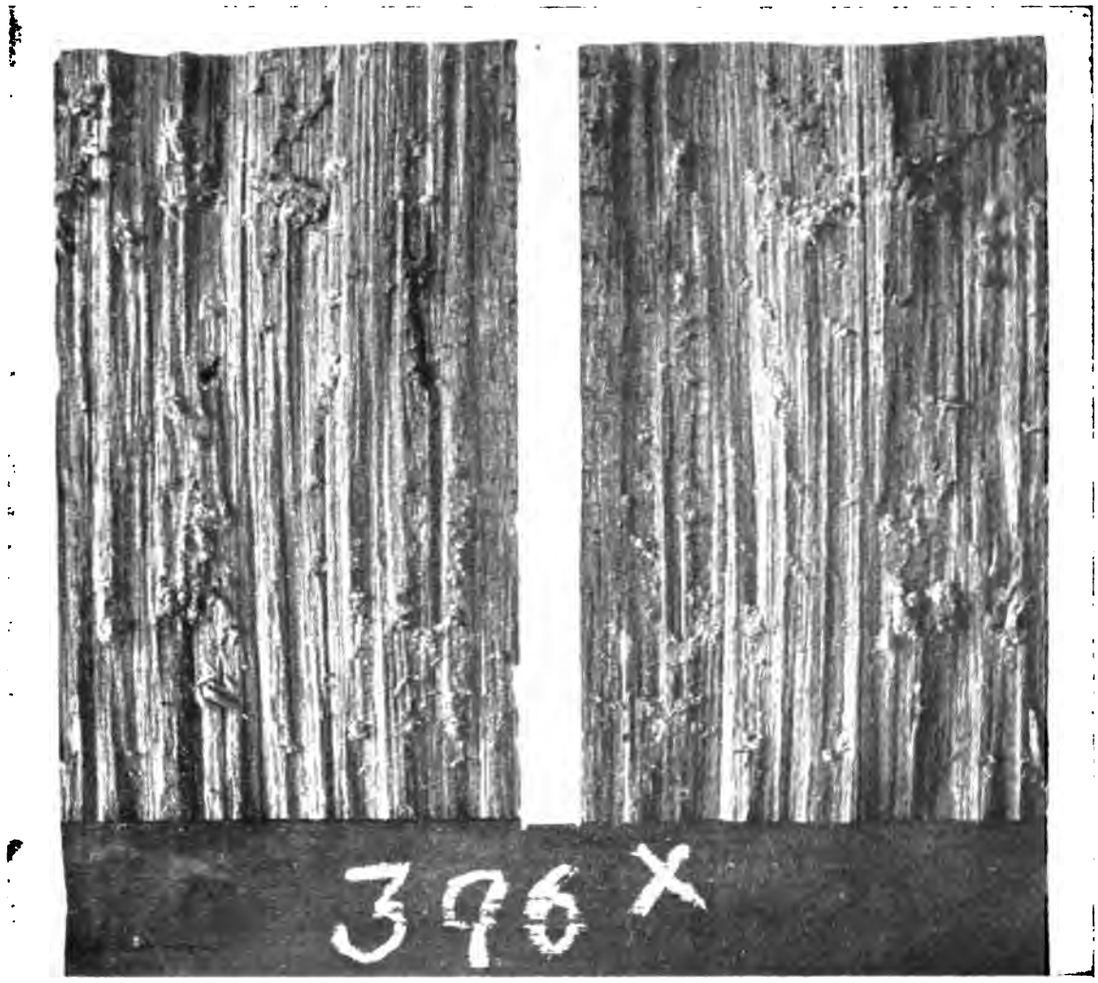
"Karri" (E. diversicolor).



"Red Gum" (E. calophylla).

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Sydney University method.

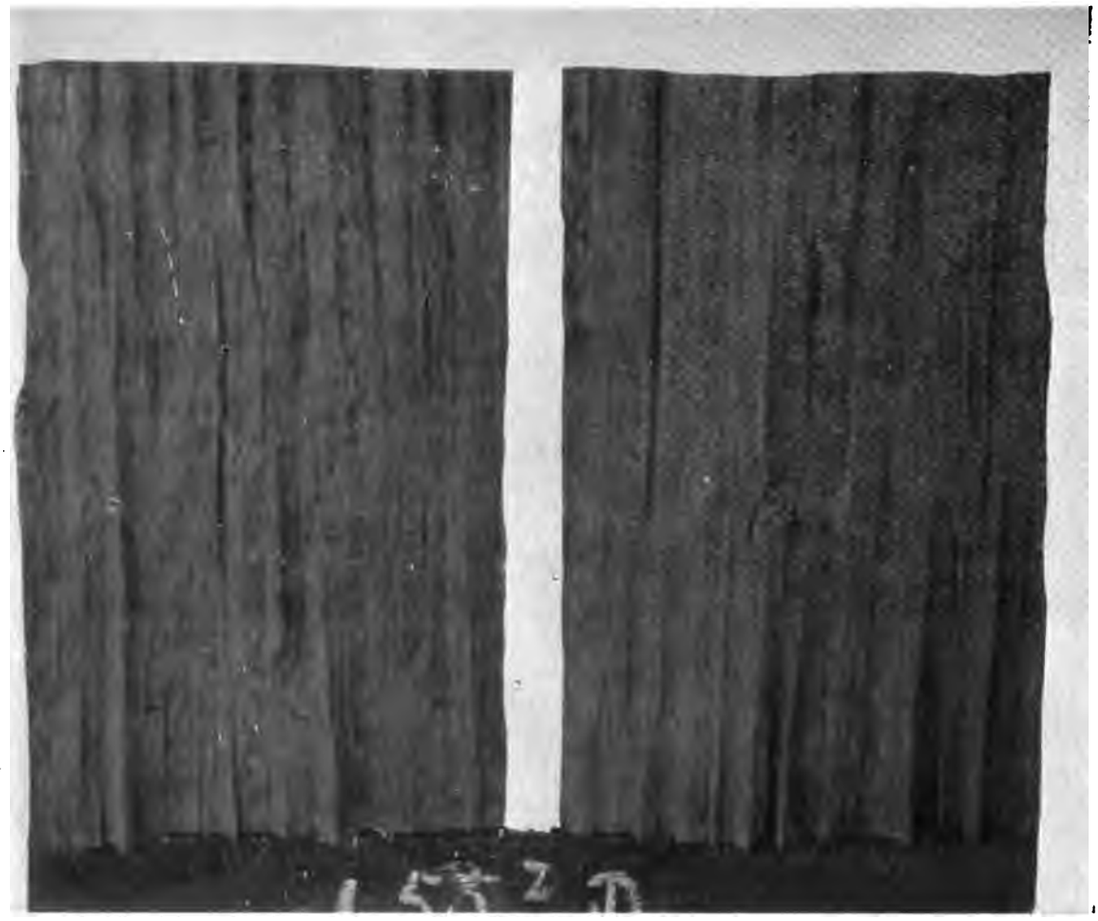


"Red Gum" (E. calophylla).

"Wandoo" (E. redunca).

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Sydney University Method.

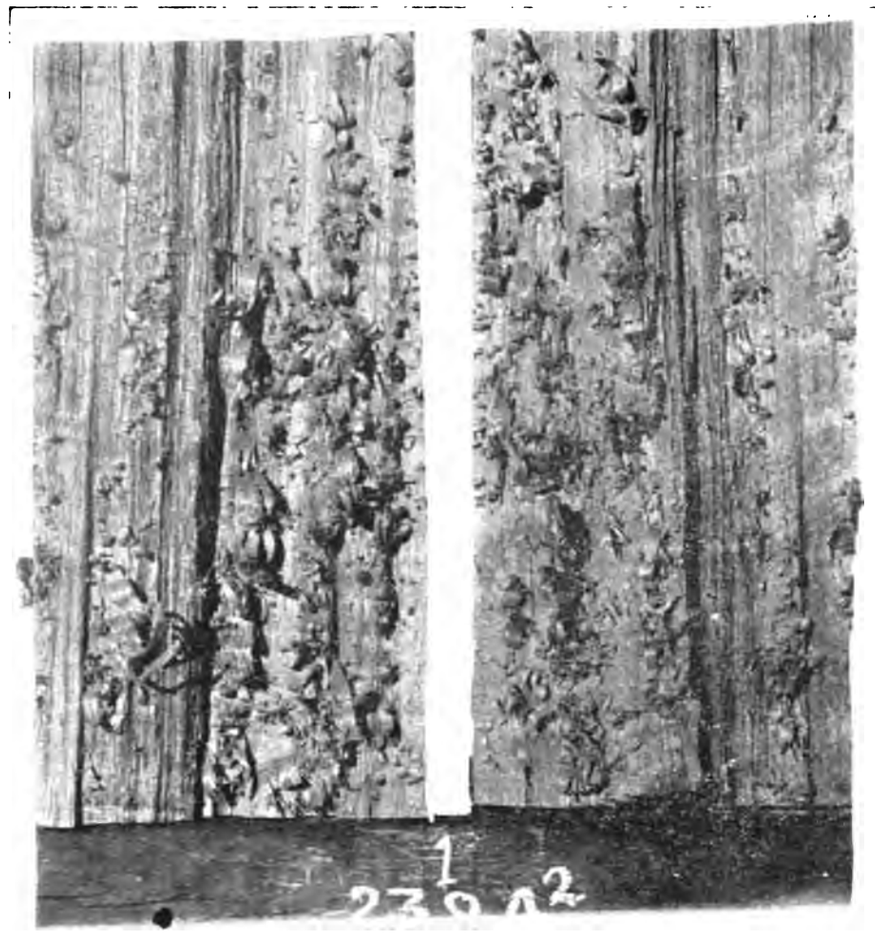


"Jarrah" (E. marginata).

"Tuart" (E. gomphocephala).

W.A. TIMBER TESTS, 1906.

"SHEARING" TESTS. SYDNEY UNIVERSITY METHOD.



"YATE" (E. CORNUTA).

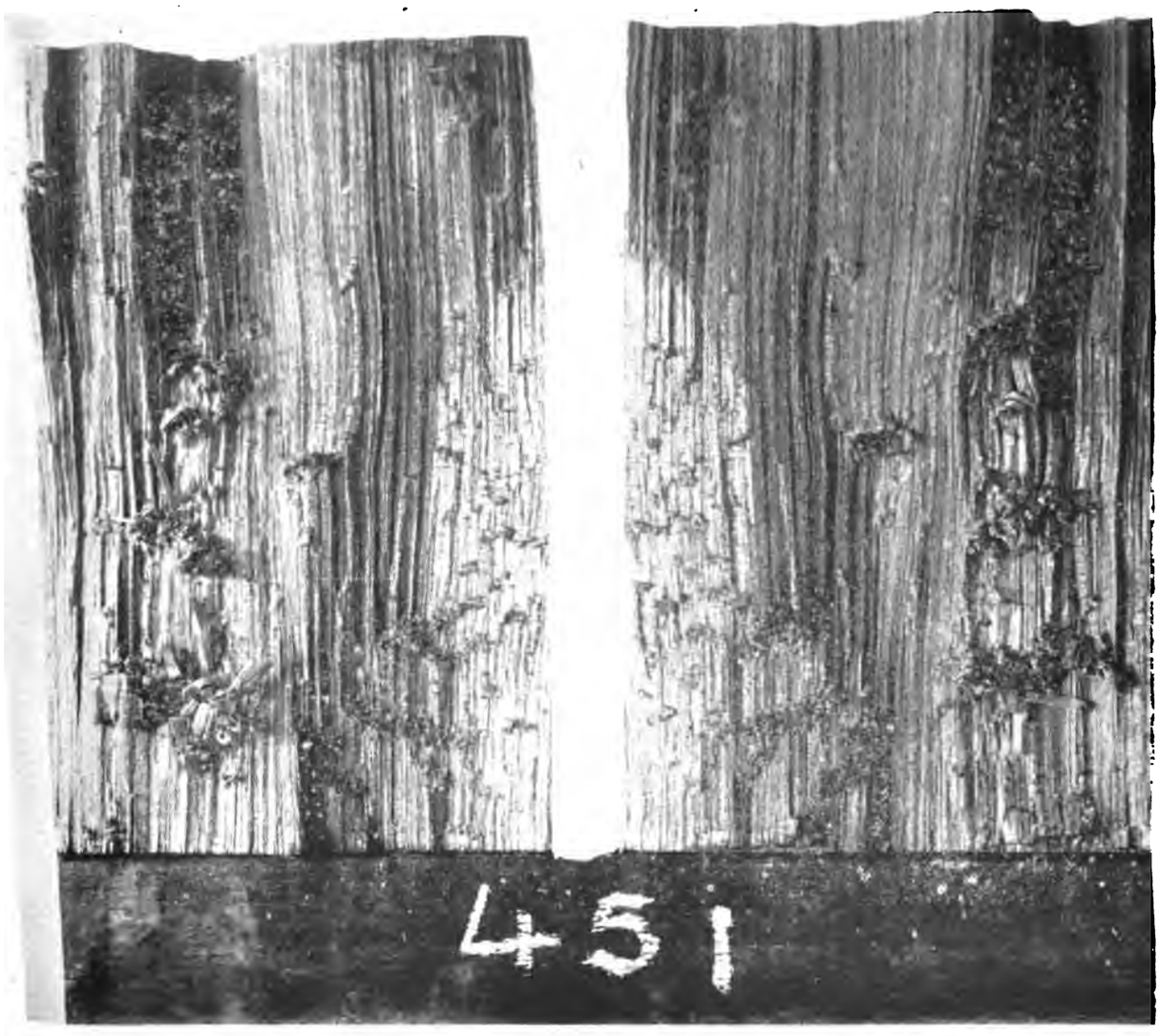
"TUART" (E. GOMPHOCEPHALA).

The great number of fibres that are subjected to and fail under a tensile stress in this method of testing

W.A. TIMBER TESTS, 1906.

"Shearing" Tests. Sydney University Method.

"Wandoo" (E. redunca).



"Blackbutt" (E. patens).

W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"TUART" (E. GOMPHOCEPHALA).

W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"JARRAH" (E. MARGINATA).

W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"BLACKBUTT" (E. PATENS).

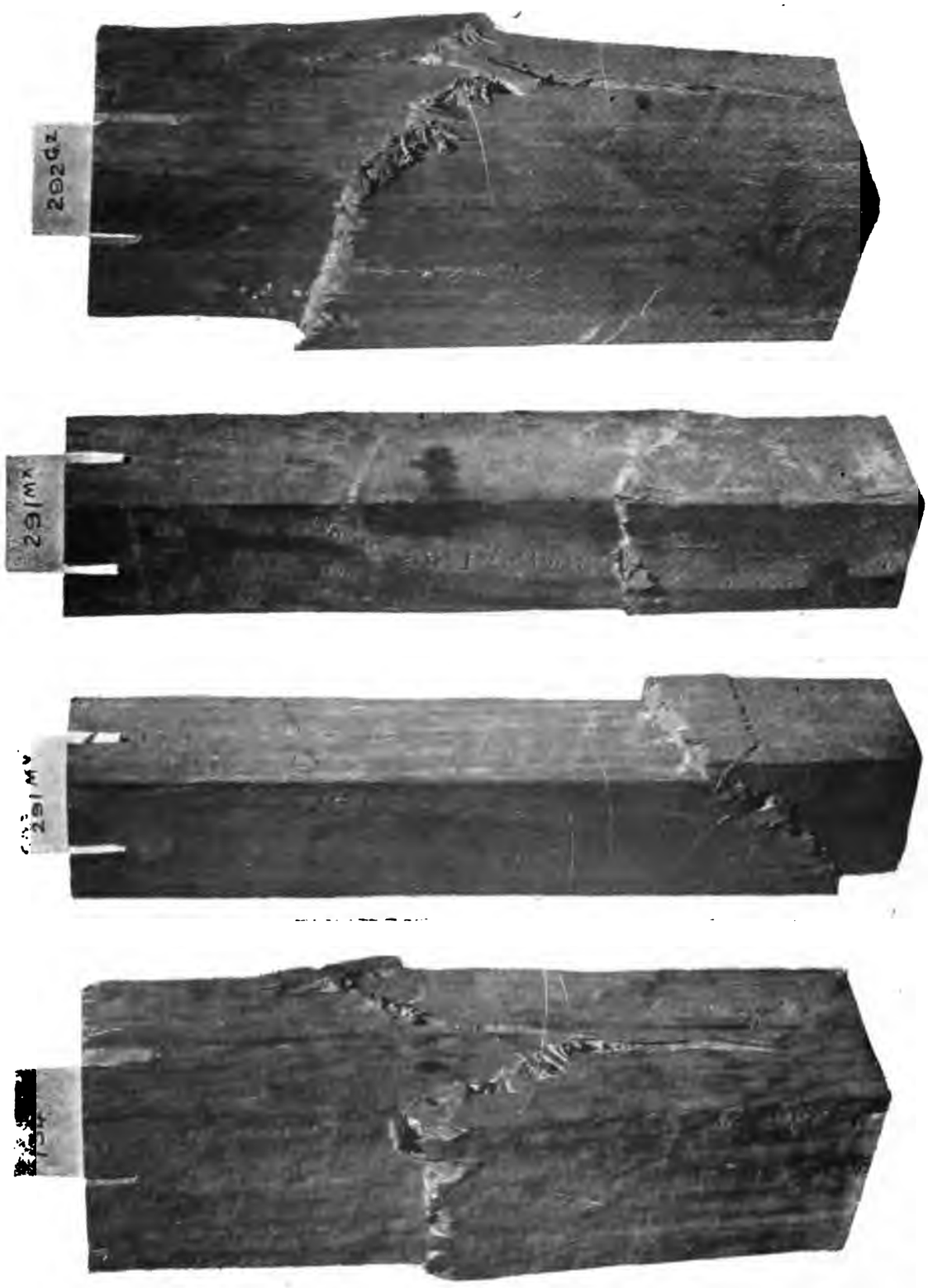
W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"YATE" (E. CORNUTA).

W.A. TIMBER TESTS, 1906.

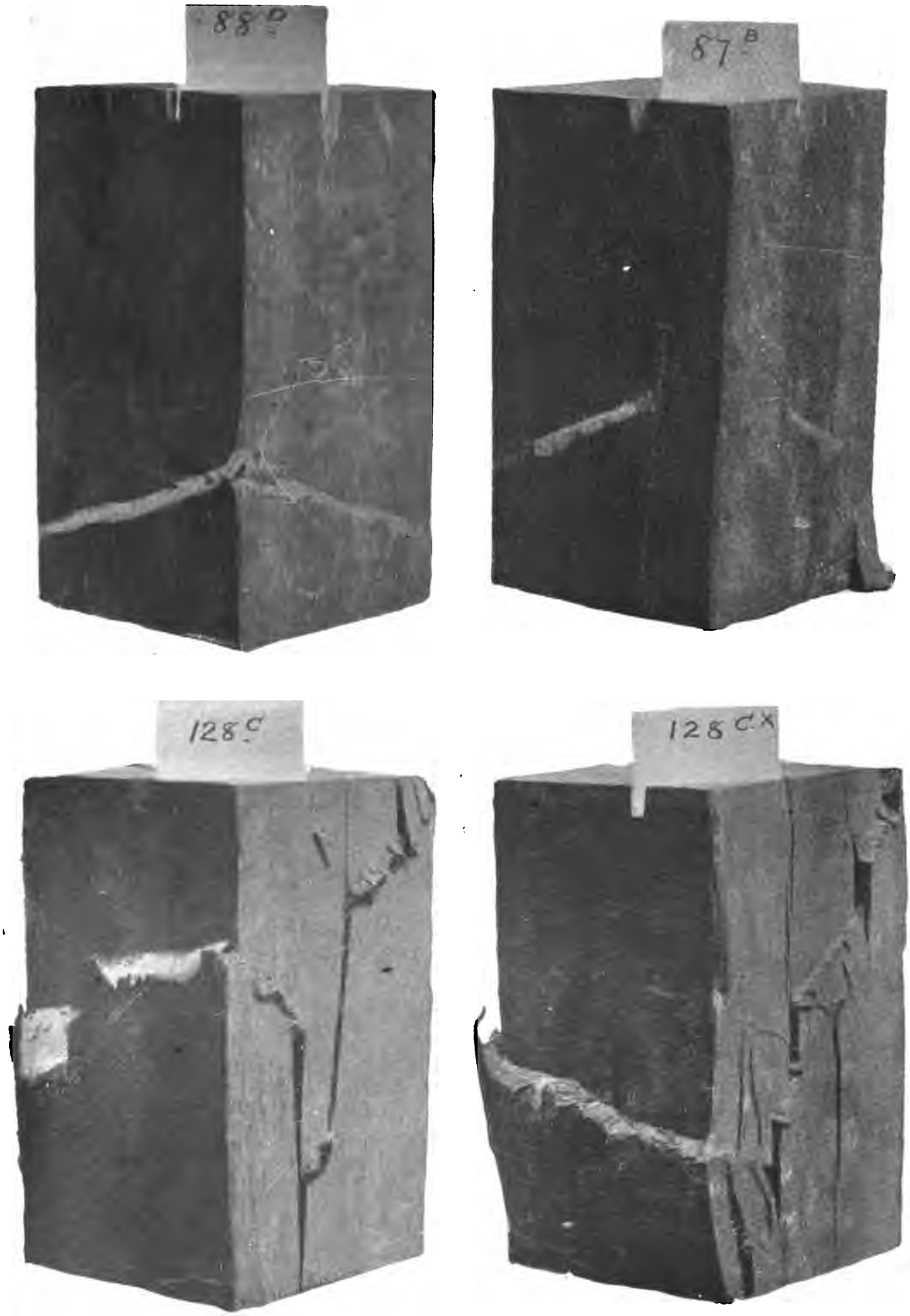
TESTS IN END COMPRESSION.



"WANDOO" (E. REDUNCA).

W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.



KARRI" (E. DIVERSICOLOR).

W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"BLACKBUTT" (E. PATENS).

W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"BLACKBUTT" (E. PATENS).

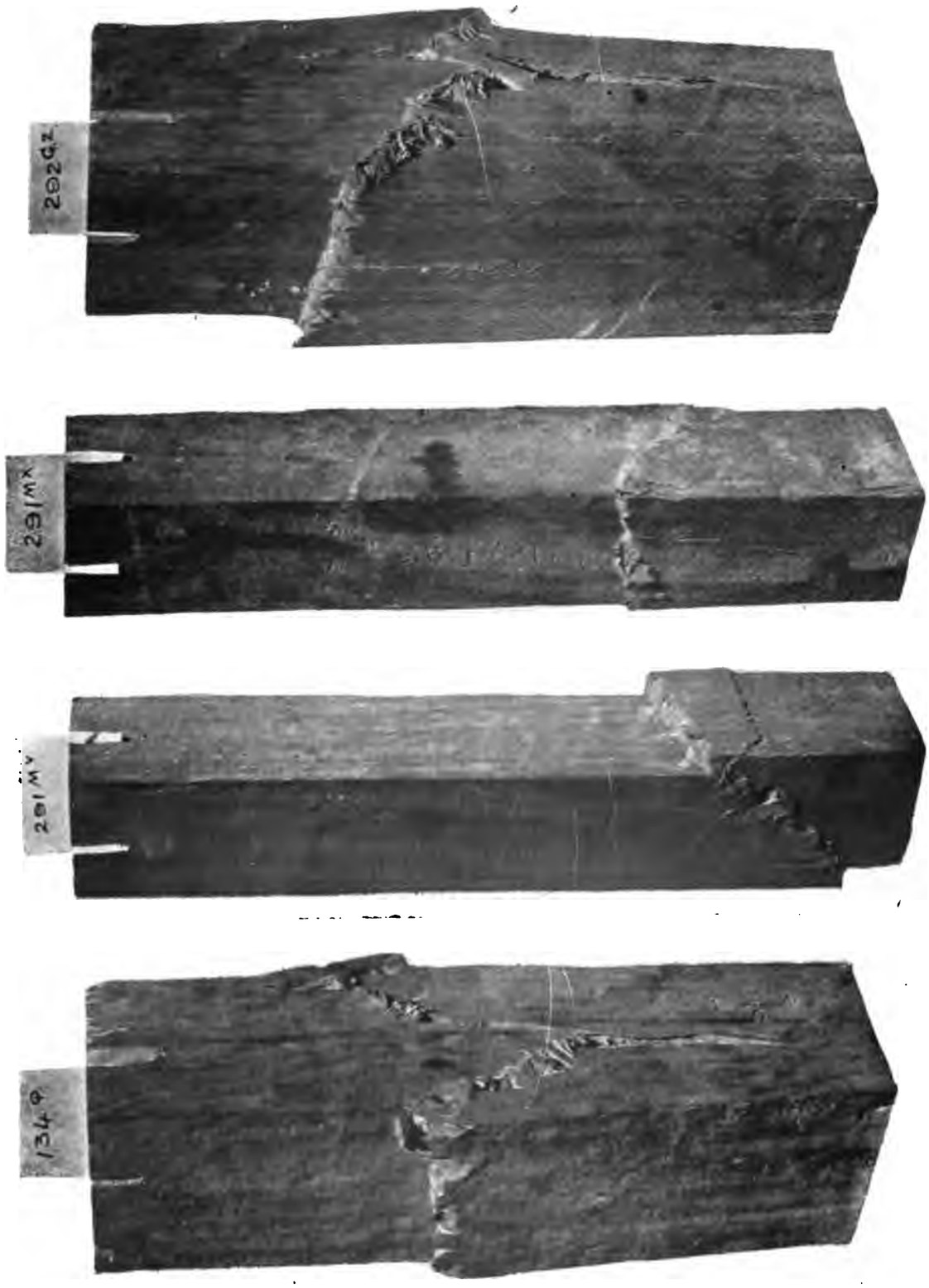
W.A. TIMBER TESTS, 1906.

TESTS IN END COMPRESSION.

"YATE" (E. CORNUTA).

W.A. TIMBER TESTS, 1906.

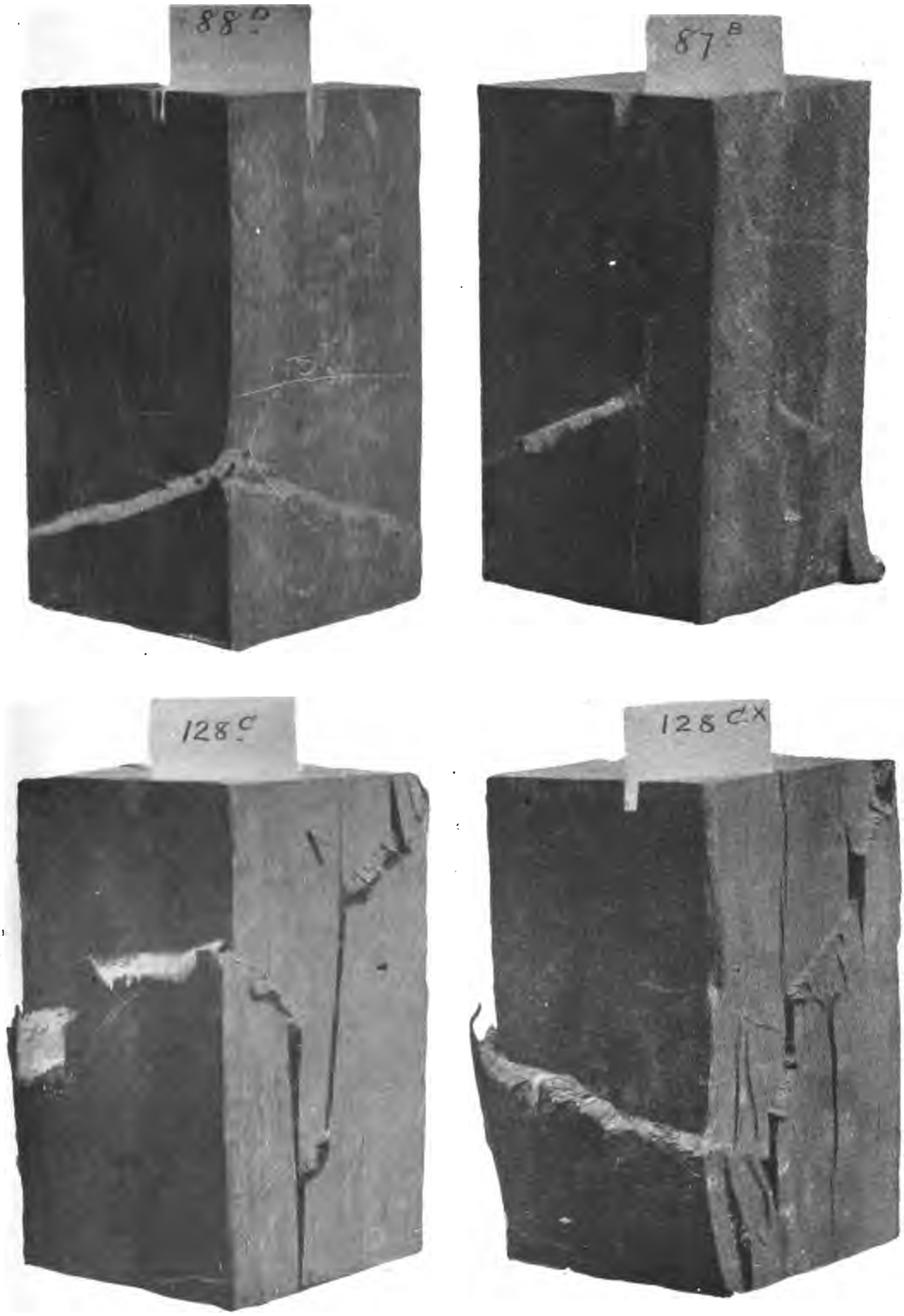
TESTS IN END COMPRESSION.



"WANDOO" (E. REDUNCA).

W.A. TIMBER TESTS, 1906.

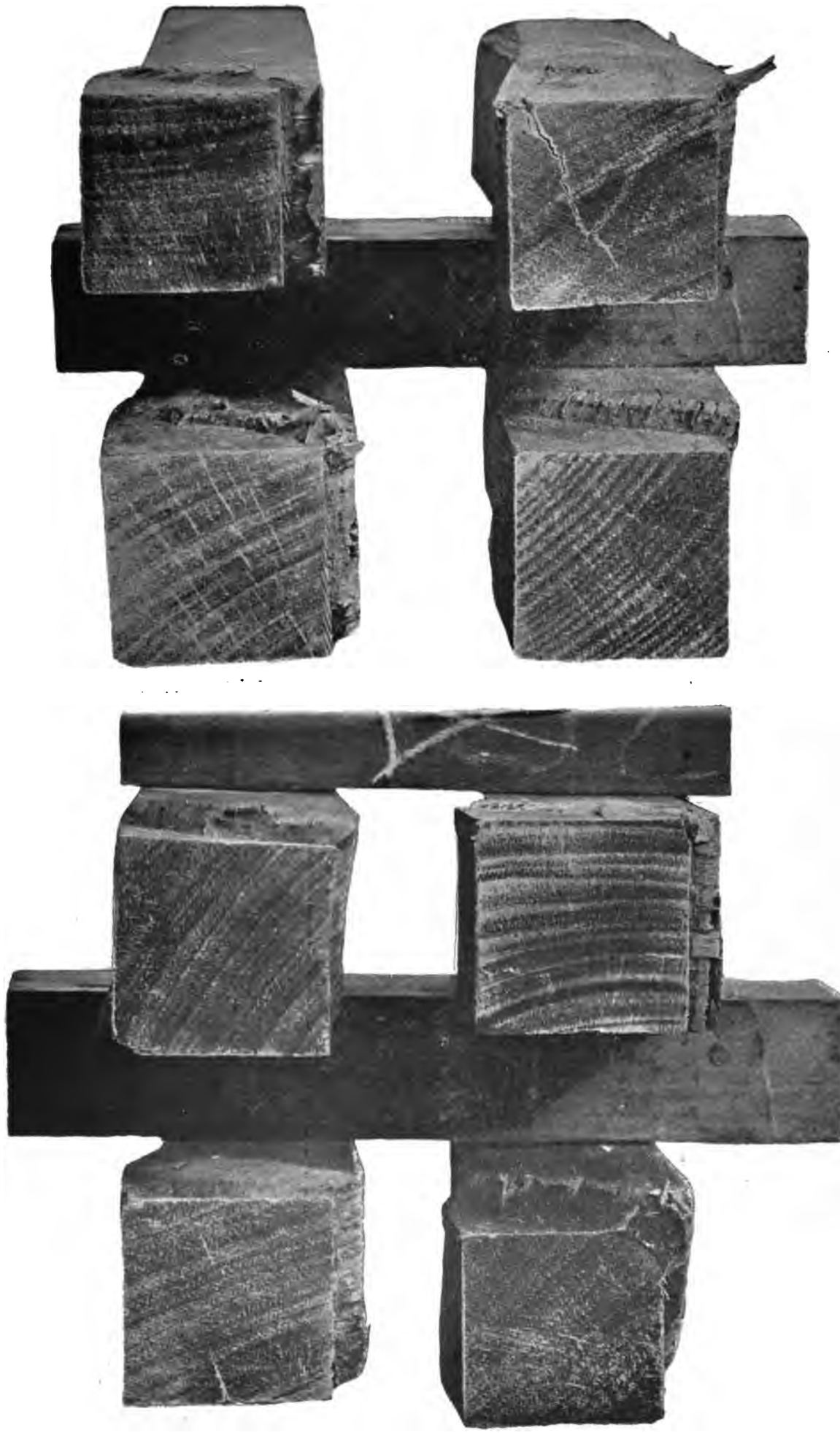
TESTS IN END COMPRESSION.



KARRI" (E. DIVERSICOLOR).

W.A. TIMBER TESTS, 1906.

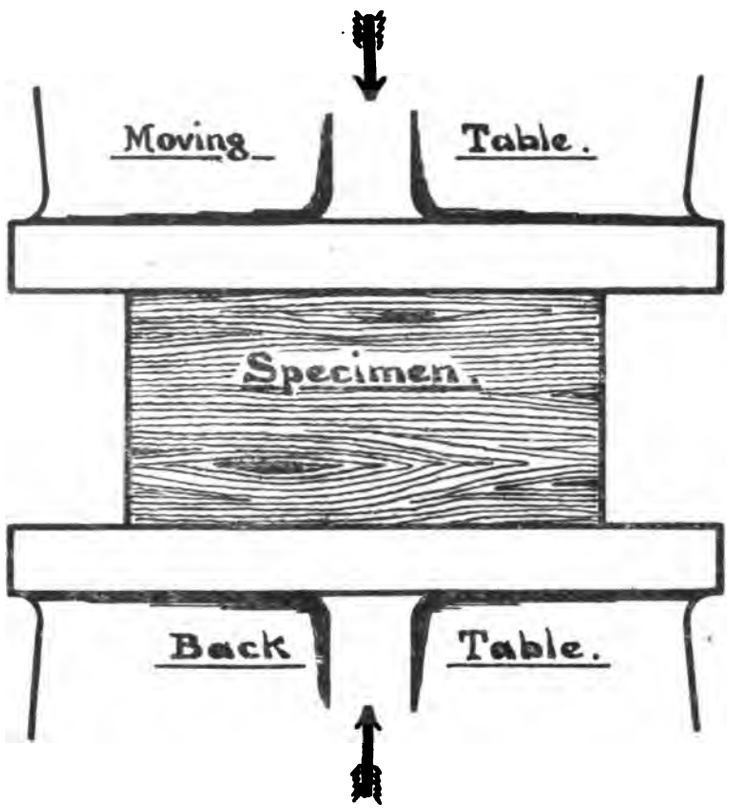
TESTS IN END COMPRESSION.



Group of tested specimens showing the relationship existing between the direction of "sliding" and the direction of the "annual rings" in the specimen.

Diagram shewing method of testing Specimens in Cross Compression.

W.A. Timber Tests.
1906.



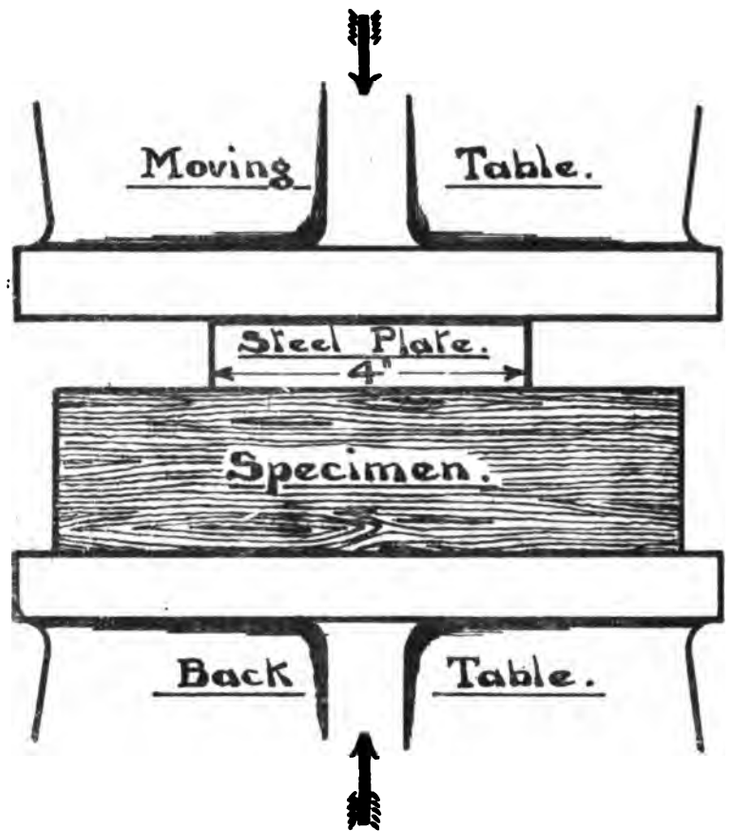


Plate No. 72.

Schedule No. 1.

V.A. Timber Tests 1906.

	palling Test lbs dropped 5 ft into cylindrical pecimen 3 in. in length sq in sechonal area ried on an anvil in in weight		Remarks.
Tim. tested in pots	No. of Blows sustained.		
	Before failure commenced	Before complete failure	

3 2044 102 888